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# NUCLEAR REGULATION

# Process for Backfitting Changes in Nuclear Plants Has Improved

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United States
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Comptroller General
of the United States

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To the President of the Senate and the
Speaker of the House of Representatives

This report examines the process used by the Nuclear Regulatory Commission to require modifications at operating nuclear power plants, the effect of those actions on selected facilities, and improvements that should be made.

We conducted the review because this function represents a cornerstone in the regulation of nuclear power, impacts on the health and safety of the public, and can affect the cost of electricity.

Copies of this report are being sent to the Director, Office of Management and Budget, and to the Chairman, Nuclear Regulatory Commission.

Charles A. Bowsher

Charles A. Bowsher
Comptroller General
of the United States



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# Executive Summary

Since the inception of commercial nuclear power, there has been public concern regarding its safety. Incidents such as the 1979 accident at Three Mile Island (TMI) have shown that safety problems can arise after plants are designed and built. Although the Nuclear Regulatory Commission (NRC) can require modifications—known as backfits—to nuclear plants, concern has developed within the agency and the nuclear industry that inadequate control has resulted in costly backfits—estimated by industry to be as much as $90 million at each of the 35 oldest plants—having questionable safety benefits.

Because of the importance of this issue to both public safety and the production costs of electricity, GAO analyzed NRC's

- historical backfitting activities and their impacts on nuclear power plants and
- recent initiatives to improve its backfitting process.

## Background

Currently, 86 operating nuclear power plants provide about 15 percent of the nation's electricity. About 100 plants are expected to be in operation by the end of the decade.

NRC approves the safety measures incorporated into the design and operation of nuclear plants. Its backfitting regulation also permits the agency to require additional safety measures at plants already licensed for construction or operation if it finds that ". . . such action will provide substantial additional protection. . . ." Until the regulation was revised in October 1985, it did not describe how NRC was to make this finding.

## Results in Brief

In practice, NRC staff have not performed analyses to determine whether individual backfits would substantially improve safety. Instead, as part of their review of utilities' operating license applications, the staff have questioned whether utilities needed additional safety measures. While these measures were not formally required, utilities usually implemented them because it was more cost-effective than delaying plant operations until NRC's questions were formally resolved. For example, on the basis of NRC concerns, two utilities seeking an operating license installed instruments to measure the amount of a chemical used to control the nuclear reaction. These instruments cost about $100,000 per plant and increased operating complexity because of maintenance and monitoring requirements. Subsequently, however, the agency decided

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that potential accidents related to improper use of this chemical would not present a significant public safety risk.

Late in 1981 NRC began requiring its senior management to review proposed backfits and analyses of their safety benefits and costs. However, the NRC staff continued to raise safety concerns that resulted in new backfits. In these cases, the required analyses to justify the change were not made. This situation occurred because of the agency's decentralized organization and continuing disagreement among the staff over what constituted a backfit.

On October 21, 1985, NRC revised its backfitting regulation. In conjunction with changes NRC is also making to its management systems, the framework for effective backfitting management is now in place.

## Principal Findings

### Past Backfitting Activities

Individual units of NRC's decentralized staff have raised safety concerns that utilities believed must be met as a condition for obtaining approval to operate their plants. In these cases, however, NRC did not perform detailed analyses of the resulting benefits and costs or determine whether the change would provide "substantial additional protection". (See p. 37.)

NRC has found that these types of backfits have not always had a positive impact on nuclear power plant safety. For example, NRC found that a revised requirement for testing the reliability of diesel generators that provide a standby source of plant electricity actually decreased the reliability of this backup safety equipment. (See p. 40.)

### New Backfitting Systems

In 1981 NRC took steps to better manage backfitting. It created a senior management committee to review those backfits that apply to several or all plants, developed another management system for backfits that apply to features unique to one plant, and required documented analyses of the estimated safety benefits and costs of proposed backfits. Although the NRC staff followed the new processes in imposing some new requirements, other backfits occurred outside of the established systems. This happened because of disagreement among managers and technical staff over what constituted a backfit. (See pp. 49 and 52.)



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## Corrective Measures

GAO found that three basic corrective measures were needed. First, to eliminate the disagreement over what constitutes backfitting, NRC needed to define more precisely what it means by backfitting. The agency's new backfit rule does this. It defines a backfit as any new or amended NRC regulation or new staff interpretation of a regulation that is imposed after a utility has received NRC approval to construct a facility.

Second, to ensure that backfits receive appropriate senior management review, NRC should not require utilities to comply with new or modified regulations or staff positions unless they are imposed by a designated NRC official on the basis of documented analyses that demonstrate that they provide a substantial increase in protection. The new backfit rule, in conjunction with changes to the backfitting management systems, satisfies this requirement.

Third, and fundamental to effective management of backfits, NRC should periodically assess the performance of its managers and staff in adhering to the new backfit rule and management systems. In commenting on the report, NRC said that it established performance criteria relative to backfitting in January 1985 for its senior managers and a computerized data base in June 1985 to monitor how backfits are managed. It is too early to assess the effectiveness of these efforts. Because of past difficulties in getting staff to recognize new requirements as backfits and submit them for the required review and approval, however, GAO believes that in assessing the performance of its managers and staff, it is important that NRC consider who is initially identifying backfits. Any instances in which utilities identify backfits that were not subjected to prior analysis and review could represent a breakdown in NRC's management of backfits. (See p. 69.)

## Recommendations

GAO believes the principal elements for effective backfitting management are in place; but it is too early to evaluate the effectiveness of their implementation. GAO is recommending that the Chairman, NRC, clarify certain features of the system for managing backfits. (See p. 70.)

## Agency Comments

NRC said GAO's report highlighted several areas in which additional work is desirable and continuing. The agency also noted that it had recently approved a new backfitting rule and revised backfitting management procedures that, in its opinion, are responsive to the report. GAO agrees and has modified the report to recognize NRC's recent actions.

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NRC also highlighted other actions it is taking to assist in the identification, review, and management of backfitting. GAO believes these are positive steps, but more time is needed to measure their effectiveness. (See app. I.)



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**Abbreviations**

| | |
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| ACRS | Advisory Committee on Reactor Safeguards |
| AEC | Atomic Energy Commission |
| CRGR | Committee to Review Generic Requirements |
| DOE | Department of Energy |
| EOF | emergency operations facility |
| GAO | General Accounting Office |
| GPU | General Public Utilities |
| HMR | Hydrometeorological Report |
| NRC | Nuclear Regulatory Commission |
| RCED | Resources, Community, and Economic Development Division |
| TMI | Three Mile Island |
| TVA | Tennessee Valley Authority |



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# Introduction

Electrical power generation by means of nuclear power plants began in 1957 with the operation of the 60 megawatt[1] commercial reactor located in Shippingport, Pennsylvania. Nuclear power plants have since grown in size to facilities capable of producing over 1,200 megawatts from a single unit and about 3,200 megawatts from up to three units at a single location. The 86 units in commercial operation have a total generating capacity of about 69,000 megawatts and produced about 15 percent of the nation's 1984 electricity supply. Another 33 power plants, with a planned generating capacity of approximately 37,000 megawatts, are under construction. Utilities in the United States have accumulated 870 years of operating experience with commercial nuclear power plants.

The federal government has regulated the commercial uses of nuclear energy for electrical power production since the early development of this technology. The Atomic Energy Act of 1954 (42 U.S.C. 2011) authorized and encouraged the Atomic Energy Commission (AEC) to both develop and regulate commercial nuclear power. Because of the potential conflict between the development and regulation of nuclear energy, however, these dual responsibilities were divided by the Energy Reorganization Act of 1974 (42 U.S.C. 5801). The act created the Nuclear Regulatory Commission (NRC) and transferred to it all licensing and related regulatory functions that were formerly assigned to AEC. It also abolished the AEC and assigned federal nuclear energy development activities to the Energy Research and Development Administration. The functions of that agency were incorporated into the Department of Energy (DOE) in 1977.

NRC's mission is to ensure that all commercial uses of nuclear materials and facilities are conducted in a manner that protects public health and safety, environmental quality, the common defense and security of the country, and complies with antitrust laws. NRC regulates all commercial aspects of nuclear energy from the processing of uranium ore to the disposal of radioactive wastes from nuclear power plants. Its major focus, however, is on regulating the construction and operation of nuclear power plants. Although the Atomic Energy Act of 1954, as amended, makes utilities principally responsible for properly constructing and safely operating their plants, it also charges NRC with ensuring that the utilities fulfill their responsibilities.

[1]A megawatt, equal to one thousand kilowatts, is approximately the amount of electricity needed to supply a population of 1,000.

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NRC is headed by five commissioners appointed by the President. The President also designates one commissioner as the Chairman. The principal duties of the Commission are to establish agency rules, regulations, and policies, and approve or disapprove license applications and other regulatory proceedings that come before it. The Commission has seven staff offices to assist in carrying out these functions. In addition, the agency has a senior staff officer, called the Executive Director for Operations, who heads a staff of about 3,000 persons who review license applications, conduct inspections, manage research, monitor the nuclear utility industry, and perform other agency support functions.

A utility must obtain a construction permit from NRC before it can build a nuclear power plant. The permit application, generally comprising large volumes of material, shows how the utility intends to design and build the plant in compliance with all applicable NRC regulations on design, construction, site safety, security, and environmental protection. The application also addresses how the project will comply with federal antitrust statutes. The NRC staff reviews the application to determine whether the proposed plant meets all applicable regulations. In the areas of nuclear safety, security, and environmental protection, the NRC staff review is conducted in accordance with its Standard Review Plan. This plan provides the detailed criteria used by the staff to evaluate the proposed plant and describes the procedures to be followed in performing the safety, security, and environmental reviews. When the NRC staff is satisfied that the proposed plant meets the criteria, it prepares safety and environmental reports summarizing the results of its review. Following a safety review of the utility's application by NRC's Advisory Committee on Reactor Safeguards (ACRS),[2] a public hearing, and an affirmative NRC decision, the utility receives its construction permit. The construction permit specifies the legally binding terms and conditions that the utility must comply with in completing the design and construction of its plant.

About 2 or 3 years before plant construction is completed, the utility applies for an operating license and NRC follows a similar review process. In this case, however, the utility's application describes in more detail how the plant has been designed and built to comply with NRC's regulations, the criteria that the utility committed to follow (when it received a construction permit) in designing and constructing the plant,

[2]The Advisory Committee on Reactor Safeguards is a statutorily created committee, consisting of a maximum of 15 members, that advises the NRC commissioners on nuclear regulatory matters.



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and all other terms and conditions of the construction permit. In addition, the utility submits proposed technical specifications setting out the particular safety and environmental measures and conditions that it must meet to operate the plant. Following satisfactory completion of NRC staff and ACRS reviews, as well as hearings if requested by the public, NRC issues the utility a license to operate the plant if it determines that

- the plant has been constructed in accordance with the Atomic Energy Act of 1954, as amended, other applicable federal laws, the Commission's rules and regulations, and the terms and conditions of the construction permit, as amended, during the operating license review and
- there is reasonable assurance that the operation of the plant will not endanger the public health and safety.

After the plant begins operation, and throughout its life, NRC monitors its activities through inspections, analyses, and reviews of utility operational reports. NRC also attempts to ensure that utilities always comply with the appropriate operating standards so that safety is continuously achieved.

## NRC Requires Changes to Maintain or Improve Nuclear Plant Safety

One of NRC's regulatory responsibilities is to identify new safety and environmental issues and ensure that the appropriate action is taken to resolve issues that arise throughout the nuclear industry. These issues develop from experience at operating reactors or from knowledge gained through new analyses or research. For example,

- NRC and independent investigations of the March 1979 accident at the Three Mile Island nuclear power plant in Pennsylvania concluded, among other things, that utility staff training and emergency response capability was inadequate for accident situations.
- NRC investigations of the failure of reactor systems to automatically shut down the Salem nuclear plant in New Jersey determined that critical components had not been properly maintained.
- Reanalysis using computer models of the capability of nuclear power plants to withstand earthquakes disclosed that potential safety problems existed with some cooling water pipes in plants and their attendant supports.

To resolve these kinds of issues, NRC may modify its existing regulations, develop new regulations, or offer detailed NRC staff guidance for evaluating utility compliance with the applicable regulations.

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Utilities applying for construction permits must comply with new or revised regulations as well as detailed NRC staff guidance. Depending on its importance, however, NRC may or may not choose to impose the new requirement on plants that are already under construction or licensed for operation. An NRC decision to impose a new requirement on a plant under construction or operating is commonly called backfitting. NRC's authority to backfit nuclear power plants comes from the Atomic Energy Act of 1954, as amended, which states that the terms and conditions of licenses shall be subject to amendment, revision, or modification by reason of amendments to the act and NRC's rules and regulations.

NRC established a backfitting regulation in 1970 (Title 10 of the Code of Federal Regulations, section 50.109). The regulation stated that

"The Commission may . . . require the backfitting of a facility if it finds that such action will provide substantial additional protection which is required for the public health and safety or the common defense and security. As used in this section, 'backfitting' of a production or utilization facility [including a nuclear power plant] means the addition, elimination or modification of structures, systems or components of the facility after the construction permit has been issued."

Although this definition applies to hardware changes after NRC has issued a construction permit, for reasons that are discussed later in this report, any plant-related changes or analyses that NRC requires to plants under construction or in operation are generally referred to within the nuclear industry as backfits. Thus, the term "backfit" is generally used to cover a range of NRC-required activities that is broader than the way the term is defined in NRC's regulations. This definition of backfitting was in effect through the end of our review. As discussed in chapter 3, NRC modified the definition of backfitting effective October 21, 1985.

NRC has required backfitting on plant components that are critical to the safe operation of the nuclear reactor, such as the automatic systems that shut the reactor down in the event of an emergency, and for activities that have no direct relationship to the operation of the nuclear reactor, such as guarding the perimeters of power plants. The following pictures illustrate two backfits that have been performed at nuclear power plants. The first group of pictures (figs. 1.1, 1.2, and 1.3) shows an emergency off-site facility to be used to monitor the plant conditions and provide information to the public in the event of an accident. Following the Three Mile Island accident, NRC required utilities constructing and operating nuclear power plants to build these facilities. The second



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set of pictures (figs. 1.4 and 1.5) shows modifications to pipes carrying cooling water inside an operating plant, which NRC required to prevent pipe breaks or ruptures that could be caused by an earthquake.

**Figure 1.1: Emergency Operations Facilities**

Emergency operations facility, Commonwealth Edison's Dresden and La Salle County stations, Illinois.

Emergency operations facilities (EOFs) were required at nuclear power plants following the accident at Three Mile Island. Some were located very close to the facilities, as shown in figure 1.2 in the photo of Northern States Power's Prairie Island station (see arrow). In some cases, a single EOF services two nuclear stations, as with Commonwealth Edison's Dresden and La Salle County units (fig. 1.1). All of these facilities are intended to improve the coordination of emergency response actions among plant personnel and federal, state, and local government representatives. An emergency response drill is shown at the Prairie Island station (fig. 1.3).

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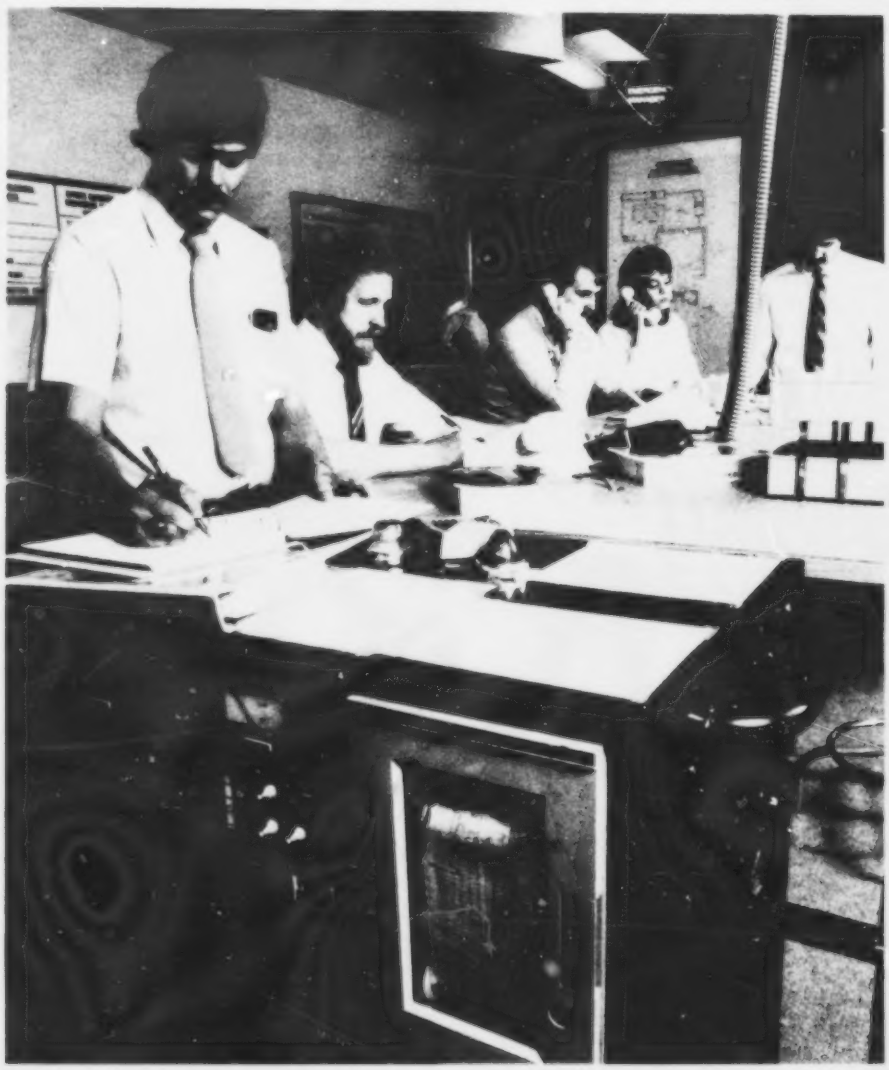
Figure 1.2: Emergency Operations Facilities

Prairie Island Nuclear plant with emergency operations facility in lower right hand corner of picture.

**Figure 1.3: Emergency Operations Facilities**



Inside an emergency operations facility during emergency response drills



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Figure 1.4: Pipe Snubber

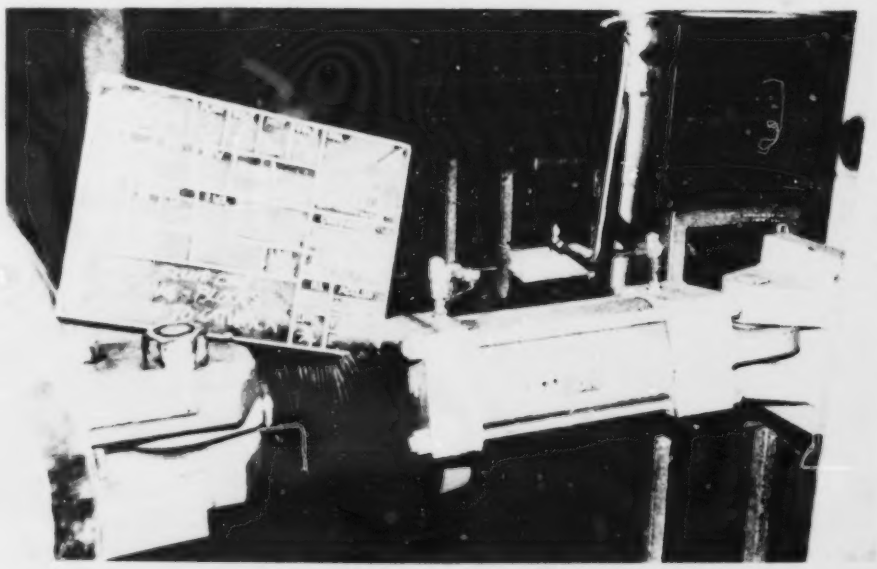
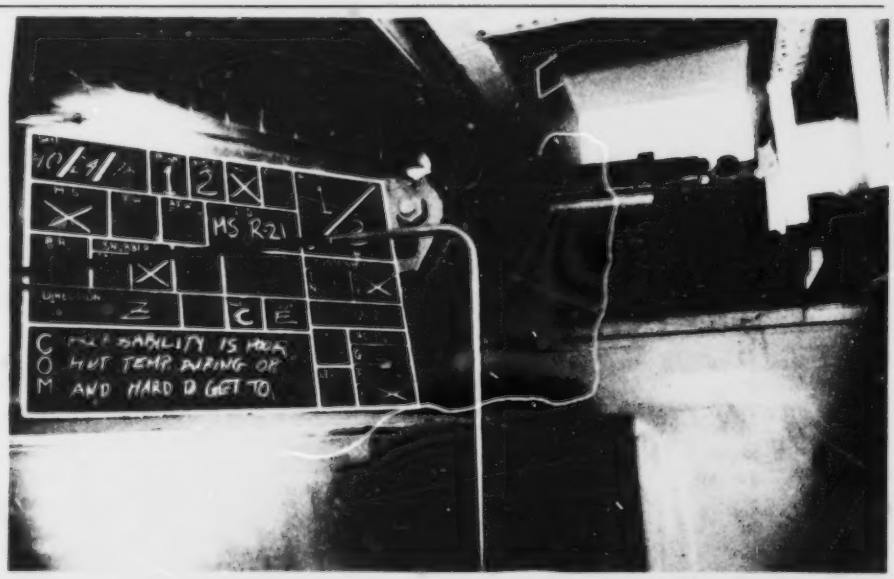


Figure 1.5: Pipe Snubber




The pipe snubbers shown in figures 1.4 and 1.5 are hydraulic devices, similar to shock absorbers in an automobile, used to restrict movement of pipes during an earthquake. While they would be necessary during such a catastrophe they can cause difficulties during normal operations. Snubbers must be periodically inspected and tested. Since they are generally attached to pipes carrying highly radioactive cooling water, they also expose plant personnel to radiation.



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## Controversy Over Backfitting

Implicit in an NRC decision to require backfits at nuclear power plants under construction or in operation is an engineering judgment that the safety, security, or environmental benefits to be achieved will outweigh the associated costs. Backfitting costs include the direct costs of design, procurement, and installation as well as their indirect costs, such as the purchase of replacement electrical power while plants are shut down to perform the backfit. Finally, noneconomic costs, such as worker exposure to radiation during installation, may also be significant. Because assessing and weighing the potential safety, security, and environmental benefits against direct, indirect, and noneconomic costs is a highly subjective process, backfitting has been a controversial NRC activity.

The extent that backfitting has occurred at nuclear power plants cannot be accurately determined because NRC has not compiled detailed data on the number of backfits and their associated costs and benefits. However, the President's Private Sector Survey on Cost Control estimated that the cost of installing NRC-required backfits at the 41 operating plants that it examined averaged about $55 million per plant through 1982. These estimates closely approximate the 1983 findings of an NRC task force on regulatory reform.

The nuclear industry has voiced concern about NRC's procedures for backfitting new regulatory requirements on operating plants and plants under construction. The industry maintains that backfitting has contributed to high nuclear power plant costs and, in some cases, little, if any, additional safety benefits. It contends that NRC has allowed its staff to arbitrarily impose backfits without a justifiable basis in improved safety, security, or environmental protection; this, in turn, has resulted in uncertainty, confusion, and unnecessary additional costs to utilities. Both the Private Sector Survey and DOE have identified backfitting as the primary area of nuclear regulation in need of reform.

Conversely, public interest groups such as the Union of Concerned Scientists contend that as knowledge is gained from operating experience, backfits have been necessary to bring plants up to standards that were in effect when the plants were licensed. Therefore, these groups maintain that regulatory policies and procedures that would inhibit the backfitting of new regulatory requirements on operating nuclear power plants and plants under construction are unwarranted.

NRC has recognized that it has not always adequately considered and weighed the added benefits of proposed backfits against their costs before imposing new requirements on utilities building and operating

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nuclear power plants. In an August 1981 report,[3] NRC concluded that the pace at which the agency was imposing new requirements on the industry had created a potential safety problem of unknown dimensions. For example, utilities reported to NRC that they had to defer major plant maintenance activities in order to provide sufficient resources to satisfy new NRC regulatory requirements and schedules for implementing the requirements. As a result, NRC has taken several steps to improve its management controls over backfitting, and on August 1, 1985, it revised its backfitting regulation. The revised regulation went into effect on October 21, 1985.

## Objectives, Scope, and Methodology

According to NRC's original backfitting regulation, backfitting occurs when NRC requires a utility to make changes in a nuclear power plant under construction or operating for the purpose of providing "substantial additional protection" for the public health and safety or the common defense and security. Therefore, the basic objective of our review was to determine whether NRC has regulatory policies and procedures in place that effectively ensure that it backfits plants only after finding that proposed backfits meet this criterion.

Our first objective was to gain a historical perspective on the magnitude of NRC's backfitting activities and its management methods. To do this we interviewed senior- and mid-level officials within NRC's Office of the Executive Director for Operations, Office of Nuclear Reactor Regulation (which reviews nuclear power plant license applications and monitors plant operation experience), and the Regulatory Reform Task Force (established to study NRC's regulatory processes and recommend reforms). In conjunction, we reviewed various NRC documents supplied by these officials on the backfitting issue. We also interviewed representatives of the Atomic Industrial Forum[4] and three utilities having the largest number of nuclear power plants. They are the Commonwealth Edison Company, Chicago, Illinois; Duke Power Company, Charlotte, North Carolina; and the Tennessee Valley Authority (TVA), Chattanooga, Tennessee. At the time of our visits, these utilities were operating 18 nuclear power plants and were constructing another 10 plants. We obtained and reviewed documentation from these utilities on the

[3]NRC, A Survey by Senior NRC Management to Obtain Viewpoints on the Safety Impact of Regulatory Activities from Representative Utilities Operating and Constructing Nuclear Power Plants (Aug. 1981).

[4]The Atomic Industrial Forum is an organization of nuclear utility industry companies formed to foster the development and utilization of atomic energy for peaceful purposes.



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backfits imposed by NRC on their nuclear plants, the costs of those backfits, and their views on the related safety benefits. We also visited TVA's Sequoyah plant and the Commonwealth Edison Company's Zion plant to observe backfits that had been or were being installed.

It soon became apparent that we would not be able to identify all NRC backfits from which to select a representative sample for detailed review because NRC did not identify which new regulatory requirements were or were not backfits when imposing the requirements on nuclear power plants under construction or operating. Therefore, we directed our work toward

- obtaining a qualitative perspective on the impacts of backfitting that includes the extent of backfitting, related costs, and safety benefits;
- identifying the methods NRC used to impose backfits that have led to the controversy over backfitting; and
- evaluating NRC's management initiatives beginning late in 1981 to determine whether they provided an effective means of ensuring that backfits, in the agency's view, provide "substantial additional protection."

## Obtaining a Qualitative Perspective on the Backfitting Issue

We built upon information previously gathered from utilities by NRC's Regulatory Reform Task Force that identified—from utilities' points of view—backfits and their associated costs that had been imposed on 35 operating nuclear power plants as of December 1982. We compared this cost information with the estimate of backfitting costs contained in the Private Sector Survey report. These two sources were the only estimates of backfitting costs that we were able to identify.

Using the Regulatory Reform Task Force information, we obtained from 17 utilities operating the 35 plants the identity of the specific regulatory requirements that led to the backfits they had identified to the task force. As a starting point, we selected the 12 backfits that were imposed on the greatest number of plants and discussed the requirements with NRC officials at management and technical levels in the various offices, divisions, and branches that developed and imposed the requirements. We obtained and reviewed available documentation on the safety issues that led NRC to develop the requirements, the safety benefits expected, and the justifications for imposing the requirements. We also obtained the utilities' views, along with their supporting documentation, on the propriety of these NRC requirements in terms of their benefits and costs. During the course of our discussions with NRC and utility officials, other

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backfits were identified that provided an added perspective on this issue. As other backfits were identified, we performed the same type of analyses of them. In total, we reviewed in detail the process used to backfit 29 new regulatory requirements at nuclear power plants.

To identify the reasons why NRC backfits nuclear plants, we reviewed documentation pertaining to backfits identified by utilities to NRC's Regulatory Reform Task Force on seven operating plants. We limited our review to backfits imposed on these seven plants because time did not permit us to research the history of all backfits on all 35 plants, and the total volume of backfitting information provided by the utilities operating these plants was the most complete and documented.

## Identification of Backfitting Methods

To identify the various methods NRC used to impose backfitting requirements, we interviewed cognizant NRC management and technical staff officials within NRC's Office of Nuclear Reactor Regulation, Office of Inspection and Enforcement (which inspects nuclear plants), the Committee to Review Generic Requirements (CRGR) (which reviews proposed regulatory requirements that would affect groups or classes of nuclear plants), and the Regulatory Reform Task Force. Two key officials were the Deputy Executive Director for Regional Operations and Generic Requirements, who chairs the CRGR, and the head of the task force. We obtained the perspectives of all officials we talked with on the methods that NRC uses to backfit nuclear power plants and their impact on plant safety and costs. We also obtained and reviewed NRC documents discussing the justification or rationale for backfitting activities. We held similar types of discussions with officials of the three utilities we visited to obtain their perspectives on the methods NRC uses to backfit their plants and the associated problems that, from their points of view, resulted from these methods.

## Evaluation of Backfitting Management Initiatives

Since October 1981 NRC has taken several steps to better manage backfitting. It has established separate processes for generic backfits—those backfits that apply to all or groups of nuclear power plants—and backfits that apply to a specific plant or plants at a single site. We obtained and reviewed documentation on 32 backfits—7 generic and 25 plant-specific—that had been proposed under the 2 backfitting management systems. Our objective was to determine whether the backfits had been reviewed and documented as required under the separate generic and plant-specific backfitting processes.



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Through interviews with NRC technical staff members and reviews of various types of NRC documents issued to the nuclear industry, we also determined whether NRC is issuing documents that impose new regulatory requirements on nuclear power plants without the reviews and approvals outlined in NRC's new initiatives. We obtained technical engineering documentation and discussed the rationale for each backfit with the cognizant NRC project manager, and discussed certain backfits with officials in the originating office. We also visited and obtained information from the Duquesne Light Company, Pittsburgh, Pennsylvania, which had developed an extensive catalog of current backfitting problems encountered in its efforts to construct and bring its Beaver Valley Unit 2 nuclear power plant into service. In addition, we contacted 21 other utilities operating 49 nuclear plants to ascertain whether they are performing backfits, at the direction of NRC staff, that have not been controlled under the review procedures recently instituted by NRC. Appendix II is a list of these 22 utilities and the 50 nuclear plants that they operate.

## Other Review Work

In addition to the work discussed above, we discussed backfitting with the legal counsel for the Union of Concerned Scientists, an organization that has been concerned with NRC and industry efforts to maintain or improve adequate levels of safety at nuclear power plants. We also reviewed the comments NRC received from the nuclear industry and the public that led to its October 21, 1985, revised backfitting regulation. Finally, we reviewed a March 1984 internal NRC audit report addressing NRC efforts to improve backfitting management, as well as an August 1984 DOE-sponsored analysis of NRC's backfitting activities.

Our review was performed in accordance with generally accepted government audit standards during the period of September 1983 through April 1985.

Chapter 2 of this report provides a perspective on the nature and extent of backfitting that resulted in the controversy over backfitting. Chapter 3 discusses NRC's recent backfitting management initiatives, and presents the results of our evaluation of them.

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# Perspective on NRC Activities That Led to the Backfitting Controversy

To understand backfitting and the controversy over it, one needs to understand how NRC has traditionally imposed backfits, why NRC backfits, and the problems that have emanated from this backfitting approach. NRC has imposed backfits by adopting new, or revising existing, regulations and retroactively applying them to nuclear power plants under construction or in operation. In addition, NRC has backfit nuclear plants during its routine reviews of operating license applications and plant operations by requiring compliance with the latest staff guidance and interpretations of NRC's regulations as a condition for approval. NRC has not, however, explicitly labeled these requirements as backfits nor has it formally determined that they would add substantial additional protection of the public health and safety.

Estimates of total nuclear industry backfitting costs run into the billions of dollars, but there are no parallel estimates of the benefits in terms of improved safety, security, and environmental protection. Nevertheless, we found that the requirements NRC has imposed on nuclear plants that utilities consider to be backfits were imposed to either (1) bring them into compliance with the terms and conditions of their licenses, (2) correct actual or potential design deficiencies, or (3) upgrade plant safety, environmental protection, and security levels. The last two categories, we believe, can correctly be characterized as backfits because they involve changes in the utilities' plant construction permits and operating licenses. The first category, however, involves bringing plants into compliance with their licenses and these therefore should not be viewed as backfits.

Historically, NRC has not had specific procedures dedicated to managing backfitting activities. By NRC's own admission, it was not effectively ensuring that individual backfits had a positive effect on overall plant safety, security, or environmental protection. As a result, although individual backfits may have been beneficial, experience with others suggests that they have resulted in little or even potentially negative overall benefits. In addition, utilities incurred costs that could have been avoided with better NRC management of its backfitting activities.

## How NRC Imposes Backfits

NRC's backfitting regulation provides its formal mechanism for requiring utilities to make changes to their plants under construction or in operation. According to NRC, however, the backfitting regulation has been invoked only once as a basis for requiring change. That occurred in 1973, before NRC was created, when AEC imposed additional requirements for systems and components at the Indian Point Unit 1 plant

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located north of New York City. The backfit obligated the utility to improve plant protection systems, but the company decided to close the facility rather than make expensive modifications. NRC and nuclear industry officials agreed, however, that less formal forms of backfitting routinely occur. Backfitting has occurred, they acknowledged, through NRC's methods for reviewing operating license applications and for monitoring and inspecting operating plants.

NRC has almost unlimited discretion to develop nuclear power plant safety standards. The Atomic Energy Act of 1954, as amended, authorizes NRC to prescribe such regulations or orders related to the design, location, and operation of nuclear power plants as it deems necessary to protect health and to minimize danger to life or property. In response, NRC has established two basic levels of written regulatory requirements. First, there are the rules, regulations, and general design criteria (collectively referred to as the regulations) contained in the Code of Federal Regulations that utilities must meet in constructing and operating their plants. These are formal, legal requirements. For the most part, however, they are also general statements, subject to a wide range of interpretation, that do not specify the details or methods necessary to achieve compliance. Consequently, they provide little definitive technical guidance to either the utilities or the NRC staff. Backfits are imposed on the basis of these formal requirements when NRC adopts new or revised regulations and retroactively applies them to plants under construction or in operation. Seven of the 29 backfits we reviewed involved new or revised NRC regulations.

Because NRC's formal regulations establish only general safety standards, over the years its staff have developed more detailed technical interpretations of the regulations to serve as the primary tools for evaluating utility compliance with the formal regulations. The principal documents that contain detailed NRC staff interpretations and guidance include the following:

- Regulatory Guides and Branch Technical Positions describe methods acceptable to the NRC staff that utilities can use to implement specific parts of the Commission's regulations. Periodically, these guides and positions may be revised, or new guides or positions may be issued, to reflect new knowledge or experience.
- The Standard Review Plan provides the NRC staff with guidance on how to review applications to construct and operate nuclear power plants, provides information to the nuclear industry on NRC's regulatory policies and procedures, and lists NRC license review criteria such as Regulatory



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Guides and Branch Technical Positions. Like Regulatory Guides and Branch Technical Positions, the Standard Review Plan is subject to periodic revision.

- Bulletins are issued periodically by NRC to notify utilities constructing and/or operating nuclear power plants of significant new safety issues and actions the utilities must take to resolve the issues.
- NRC staff or contractor reports, called "NUREG" documents, provide technical analyses of nuclear power plant safety issues of current interest.

Official NRC policy states that utility compliance with staff interpretations and guidance is not mandatory; utilities are free to select their own methods to comply with NRC regulations. However, it is also the NRC staff's practice to seek to impose staff interpretations and guidance on utilities as enforceable conditions of their construction permits or operating licenses unless utilities select alternatives acceptable to the NRC staff. Therefore, the NRC staff interpretations and guidance function essentially as requirements and are commonly referred to within NRC as "requirements" or "regulatory requirements." Twenty-two of the 29 backfits that we reviewed in detail were imposed by these types of NRC staff documents.

On a less formal level, NRC staff members responsible for reviewing operating license applications or for monitoring or inspecting operating plants may individually discuss with utilities plant-specific changes that would be acceptable to the staff to satisfy a particular issue. As in the case of changes to the Standard Review Plan or to Regulatory Guides, utilities are not legally obligated to make plant-specific changes to conform to this informal guidance; however, utility representatives told us that they accommodate these NRC staff suggestions whenever possible in order to maintain good working relationships with NRC. The agency's senior staff officer, the Executive Director for Operations, has publicly stated that there are as many as 87 ways that NRC uses to transmit new requirements to utilities. Figure 2.1 illustrates several ways NRC has used to backfit new regulatory requirements on nuclear power plants in the area of fire protection.

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**Figure 2.1: The Evolution of Fire Protection Requirements**

In 1975 a fire disabled critical safety systems at the Browns Ferry plant near Decatur, Alabama. Ultimately, the reactor operators were able to shut the plant down safely, but it was extensively damaged by the 7-hour fire.

NRC had been aware of the risk of fire at nuclear power plants before the Browns Ferry incident and had issued general fire protection standards in the form of general design criteria. Although these standards addressed the major aspects of fire prevention, detection, and fighting, until the mid-1970's no NRC documents existed describing the required utility actions necessary to meet the design criteria.

After the fire at Browns Ferry, NRC developed detailed fire protection standards, which were issued in 1976 as a Branch Technical Position and incorporated into the Standard Review Plan. The NRC staff strongly encouraged all operating plant owners to adopt the new standards and make appropriate plant modifications.

Many utilities cooperated with NRC's efforts to upgrade the fire protection systems by making commitments, reflected as amendments to their operating licenses, to make extensive plant modifications. However, the NRC staff was not able to resolve all the outstanding issues at approximately 20 plants. To bring these remaining plants into compliance with the guidance contained in the Branch Technical Position, the NRC staff proposed that the Commission develop a rule on fire protection.

In 1980 the Commission issued the new rule, Appendix R to 10 C.F.R. 50, which outlined the fire protection standards that all plants licensed for operation as of January 1979 would have to meet. The rule laid out new, and in some cases more stringent, requirements for fire protection and required the utilities that were already making plant modifications based on the Branch Technical Position to work out new agreements with NRC.

The rule did not apply, however, to plants receiving an operating license after January 1979; therefore, the NRC staff developed fire protection guidance for these plants in its Standard Review Plan. However, because this guidance does not precisely state how adequate fire protection is to be achieved, the specific fire protection measures to be required at new plants to meet NRC's general design criteria remain the subject of discussion and interpretation between NRC staff and utilities.

NRC has used all of the types of staff-level documents described earlier to impose new regulatory requirements on operating nuclear power plants and plants under NRC operating license review. The following paragraphs describe how this is generally done.



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As discussed in chapter 1, a utility applying for a construction permit must describe how the proposed plant will comply with applicable NRC regulations and detailed requirements. Once the construction permit is issued, the utility is legally obligated to carry out the commitments it made in obtaining the construction permit. Several years later the utility submits a detailed operating license application showing how the plant has been designed and is being built in compliance with the conditions of its construction permit and any applicable new or revised NRC regulations issued since it received its construction permit. The NRC staff reviews the operating license application. The safety, security, and environmental review is conducted by about 30 organizational branches within the Office of Nuclear Reactor Regulation and one or more branches of the Offices of Inspection and Enforcement and Nuclear Material Security and Safeguards.

In the period of time between the issuance of the construction permit and the receipt and review of the operating license application, the NRC staff may have issued new and revised guidance documents. Its traditional practice has been to review and act on an operating license application using the most current set of guidance documents as its review criteria even though the application reflects a nuclear power plant being built in accordance with the regulations and NRC staff guidance that the utility agreed to follow when it obtained its construction permit.

In essence, to the extent that NRC staff guidance changes in the period between issuance of the construction permit and receipt of the operating license application, the NRC staff reviews the operating license application using criteria that differ from the criteria the utility committed to follow in its construction permit.

Almost the same situation has occurred after utilities have received their plant operating licenses. When utilities shut down their operating plants for refueling, planned maintenance, or scheduled plant modifications, they are not allowed to restart the plants without NRC's permission. These occasions usually involve plant changes that are significant enough to require operating license amendments. NRC has used these occasions to require utilities to backfit into their plants regulatory requirements promulgated after plant operating licenses were issued.

## Perspective on the Cost of Backfitting

Because of the informal ways, discussed in the previous section, that NRC has traditionally imposed backfits on nuclear power plants, neither NRC nor the utilities it regulates have maintained or compiled a complete

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data base on the number of backfits imposed on each plant, their direct, indirect, and noneconomic costs, or their benefits in terms of improved safety, security, and environmental protection. Nevertheless, two studies have attempted to estimate the direct costs of NRC backfitting activities at operating nuclear power plants.

The two principal sources of available backfitting cost data are the President's Private Sector Survey and NRC's Regulatory Reform Task Force. In 1983 the Private Sector Survey reported information on the overall cost of backfitting at 41 of the older operating nuclear power plants. The information was based on data provided by the utility industry through its representative, the Edison Electric Institute. The Regulatory Reform Task Force was established by the Commission to assess NRC regulatory practices and their impacts, and to recommend improvements. In 1983 the task force requested data on backfitting costs from all nuclear power plant operators and obtained data from 20 utilities on 35 of the older operating plants. As shown in figure 2.2, these two groups found that utilities had spent an average of about $55 million on backfitting activities at each plant. Further, NRC's task force projected that utilities would spend an average of $37 million more per plant at the 35 plants included in its study to complete work on backfits imposed by NRC as of 1982. We did not develop or obtain from other sources backfitting cost information on the other operating nuclear power plants that, together with the plants included in the reports of these two groups, make up the 85 nuclear plants in commercial operation when we completed our review. If, however, the average cost of backfitting at plants included in the two studies is typical of all 85 plants, approximately $5 billion had been spent by the utility industry on backfitting through 1982.



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**Figure 2.2: Comparison of Total Backfitting Costs**

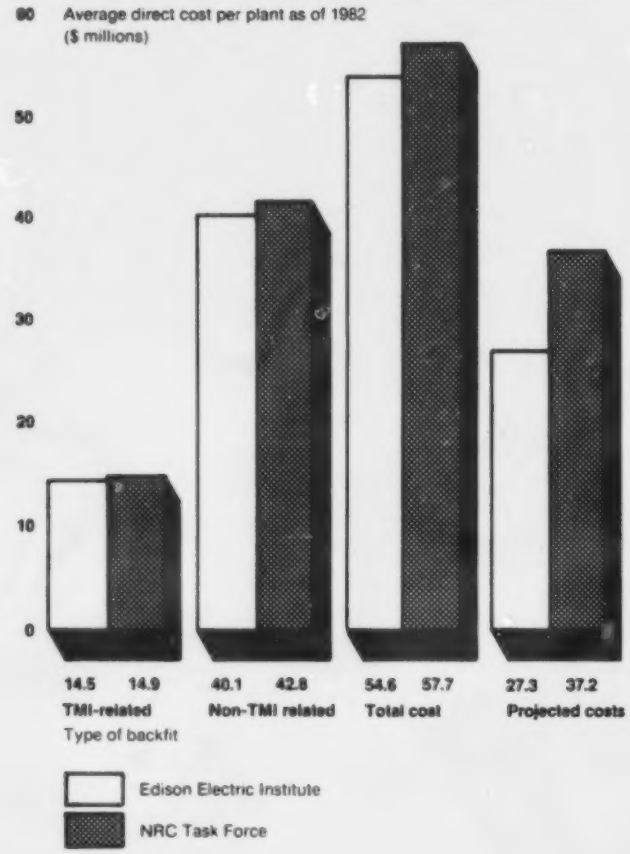


Table 2.1 shows the total backfitting costs for each plant surveyed by the NRC task force. The table distinguishes between Three Mile Island-related backfitting costs and all other backfitting costs incurred through 1982, as well as the projected costs of completing all backfits at the plants. As the table shows, utilities have already spent $2 billion and expected to spend about $1.2 billion more for a total of $3.2 billion to install the backfits NRC had imposed through 1982 at the 35 plants.

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**Table 2.1: Backfitting Costs Through 1982 Reported by Utilities to the NRC Regulatory Reform Task Force[a]**

Dollars in Millions

| Utility | Plant | TMI-Related Cost | Non-TMI Cost | Total NRC Cost | Projected Future Cost |
|---|---|---|---|---|---|
| Arkansas Power & Light | ANO 1[c] | $19.9 | $9.6 | $29.5 | $29.0 |
| | ANO 2 | 19.9 | 9.6 | 29.5 | 29.0 |
| Carolina Power & Light | Brunswick 1[c] | 7.4 | 51.9 | 59.2 | 74.0 |
| | Brunswick 2 | 7.4 | 51.9 | 59.2 | 74.0 |
| | Robinson | 7.1 | 29.0 | 36.1 | 64.0 |
| Commonwealth Edison | Dresden 2[c] | 8.8 | 53.0 | 61.8 | 36.0 |
| | Dresden 3 | 8.8 | 53.0 | 61.8 | 36.0 |
| | Quad Cities 1[c] | 8.2 | 47.5 | 55.7 | 36.5 |
| | Quad Cities 2 | 8.2 | 47.5 | 55.7 | 36.5 |
| | Zion 1[c] | 12.8 | 20.5 | 33.3 | 8.5 |
| | Zion 2 | 12.8 | 20.5 | 33.3 | 8.5 |
| Duke Power | Oconee 1[c] | 7.1 | 47.5 | 54.6 | 40.3 |
| | Oconee 2 | 7.1 | 47.5 | 54.6 | 40.3 |
| | Oconee 3 | 7.1 | 47.5 | 54.6 | 40.3 |
| GPU Nuclear | Oyster Creek | 25.1 | 110.7 | 135.8 | 108.3 |
| | Three Mile Island 1 | 38.8 | 42.7 | 81.5 | 18.0 |
| Indiana & Michigan Electric | Cook 1[c] | 11.3 | 17.6 | 28.9 | 18.2 |
| | Cook 2 | 11.3 | 17.6 | 28.9 | 18.2 |
| New York Power Authority | Indian Point 3 | 15.5 | 64.4 | 79.9 | 94.5 |
| Niagara Mohawk Power | Nine Mile Point 1 | 8.9 | 77.5 | 86.4 | 12.5 |
| Northeast Utilities[b] | Connecticut Yankee | 10.9 | 19.4 | 30.3 | 29.6 |
| | Millstone 1 | 6.6 | 108.9 | 115.5 | 42.7 |
| | Millstone 2 | 8.4 | 39.4 | 47.8 | 19.6 |
| Northern States Power | Monticello | 39.4 | 71.9 | 111.3 | 43.7 |
| | Prairie Island 1[c] | 12.9 | 19.6 | 32.4 | 21.3 |
| | Prairie Island 2 | 12.9 | 19.6 | 32.4 | 21.3 |
| Omaha Public Power | Fort Calhoun | 17.2 | 24.0 | 41.2 | 22.0 |
| Philadelphia Electric | Peach Bottom 2[c] | 10.5 | 69.7 | 80.2 | 34.1 |
| | Peach Bottom 3 | 10.5 | 69.7 | 80.2 | 34.1 |
| Portland General Electric | Trojan | 23.7 | 39.9 | 63.6 | 8.0 |
| Sacramento Municipal Util Dist | Rancho Seco | 30.4 | 32.2 | 62.6 | 66.4 |
| Toledo Edison | Davis Besse | 35.0 | 80.0 | 115.0 | 26.5 |
| Wisconsin Electric | Point Beach 1[c] | 18.8 | 14.9 | 33.7 | [d] |
| | Point Beach 2 | 18.8 | 14.9 | 33.7 | [d] |
| Wisconsin Public Service | Kewaunee | 10.9 | 7.7 | 18.6 | [d] |
| **Total** | | **$520.2** | **$1,498.5** | **$2,018.7** | **$1,191.9** |
| **Average cost per reactor** | | $14.9 | $42.8 | $57.7 | $37.2 |

[a]All costs are in dollars of the year of expenditure.

[b]Northeast Utilities also reported costs in a category it denoted as "hybrid" (utility and NRC) costs. Those costs are not included in this table.

[c]Costs are divided evenly among multiple units at the same location.

[d]No projected cost data provided by the utility.



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## Reasons for NRC's Backfitting

NRC imposes new or modified regulatory requirements on nuclear power plants to resolve issues that it believes are a threat to safe and secure plant operations or to adequate protection of the environment. NRC has not, however, labeled these requirements as backfits nor has it maintained records of the estimated safety, security, and environmental benefits of its backfitting activities. Therefore, one cannot determine why NRC imposed backfits without identifying individual backfits and reviewing each one in detail.

We were, however, able to obtain a perspective on the general reasons why NRC imposes backfits from a review of regulatory requirements that utilities identified as backfits on 7 of the 35 plants included in the study prepared by NRC's Regulatory Requirements Task Force. On the basis of our analysis, supplemented by discussions with NRC and utility officials, we found that what utilities identified to NRC's task force as backfits generally involved either

- potential noncompliance with existing NRC directives and requirements,
- potential deficiencies in existing plant designs, or
- a need for greater safety precautions than previously required.

Table 2.2 shows how the utilities' estimated costs of backfitting at the seven plants were distributed among the three general reasons why NRC imposed the backfits.

**Table 2.2: Distribution of NRC-Related Backfitting Costs for Seven Nuclear Plants**

Dollars in Millions

| Utility | Unit | Compliance | Design Deficiencies | Upgrade Safety | Other | Total |
|---|---|---|---|---|---|---|
| Northeast Utilities | Connecticut Yankee | $5.9 | $8.6 | $14.7 | $1.1 | $30.3 |
| | Millstone 1 | 55.2 | 45.8 | 14.5 | 0.0 | 115.5 |
| | Millstone 2 | 32.3 | 1.0 | 14.5 | 0.0 | 47.8 |
| Portland General Electric | Trojan | 19.5 | 7.6 | 33.3 | 3.2 | 63.6 |
| Wisconsin Electric | Point Beach 1 | 4.3 | 7.8 | 20.2 | 1.4 | 33.7 |
| | Point Beach 2 | 4.3 | 7.8 | 20.2 | 1.4 | 33.7 |
| Wisconsin Public Service | Kewaunee | 0.0 | 1.5 | 14.6 | 2.5 | 18.6 |
| **Total** | | **$121.5** | **$80.1** | **$132.0** | **$9.6** | **$343.2** |
| **Percentage of total** | | 35.4% | 23.3% | 38.5% | 2.8% | |

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## Changes Required for Compliance Issues

When inspecting and monitoring the construction and operation of nuclear power plants, NRC may find that one or more plants have not been built or operated in accordance with existing regulations or the commitments that the utility or utilities made in obtaining their construction permits or operating licenses. When this occurs, NRC requires the applicable utility or utilities to change their plants to conform with the appropriate regulations or license commitments. It may also require other utilities with similar plants to conduct inspections or perform analyses to determine whether the identified weakness also exists at their plants.

One example of this type of regulatory requirement is the seismic qualification of piping systems, which was intended to ensure that the heated nuclear fuel in the reactor core is cooled with water even under severe conditions such as an earthquake. An earthquake is a potential safety threat because it could cause the pipes that carry water to and from the reactor to break, resulting in a loss of water to cool the nuclear fuel. To avoid this situation, pipes are supported by beams and hangers to reduce pipe movement and prevent rupture during an earthquake. In 1979 NRC became concerned that errors might have been made at power plants in placing and attaching the pipe supports. This led to extensive inspections that revealed many discrepancies between the design documents utilities used to obtain their plant operating licenses and the actual configurations of the pipe systems within their plants. Subsequently, NRC's Office of Inspection and Enforcement issued two bulletins that required all utilities to inspect their piping systems and correct any deficiencies. NRC intended these requirements to ensure that plants conformed to their originally licensed designs.

These requirements have had different effects on individual plants. Officials at one utility we contacted stated that its piping system inspections identified problems with pipe supports at the plant. The bulletins brought this problem to their attention and resulted in a considerable safety improvement. Representatives of another company, however, told us that they spent over $3 million in studies and analyses of pipe support anchor bolts that showed that there were no problems at their plant. Therefore, in their opinion, this NRC requirement was not necessary.

NRC requirements of this type require utilities to comply with the terms under which their plants were licensed. Consequently, some NRC officials do not view these compliance-type requirements as backfits. Other NRC



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and utility officials pointed out, however, that when these same requirements are imposed on utilities that are not known to be out of compliance with the regulations or the conditions of their plant licenses, they represent NRC requirements that are new or in addition to the requirements under which the utilities received their licenses. Consequently, they view the application of compliance-related requirements to these utilities as backfits.

## Backfits Required to Correct Design Deficiencies

In contrast with changes that are based on noncompliance with approved designs, NRC has imposed backfits when it found deficiencies in designs or when it believed that a greater level of safety than provided in approved designs should have been achieved. Backfits to remedy design deficiencies generally arise from operating experience or engineering analyses that identify previously unknown inadequacies. A recent example involves the design and construction of the steam suppression chamber, commonly called the torus containment, of older, boiling water reactors.[1] As illustrated in figure 2.3, the torus is a structure that is designed to prevent radioactive steam, gases, and water from escaping from the reactor after an accident. Although plants with this design had been operating for several years without incident, analyses of tests from 1972 through 1974 revealed that the torus structure might not be able to withstand all the potential stresses that could arise from certain postulated accidents. After extensive study, NRC issued a NUREG document in 1980 that established criteria for the modification of all 25 plants of this design to restore the originally intended levels of safety and required the affected utilities to make plant changes necessary to satisfy the new criteria.

[1]Boiling water reactors are one of the two types of water-cooled reactors used commercially in the United States.

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Figure 2.3: Torus

General Electric Company

Figure 2.3 is an example of an early boiling water reactor design, which included a large, donut-shaped structure surrounding the reactor to capture and condense radioactive steam in the event of an accident. This "torus containment" is connected to the reactor through a series of pipes that enter the torus under water. After reactors of this design began operations, NRC determined that, in certain types of postulated accidents, fast moving volumes of steam or water could damage the internal structure of the torus containment, thereby reducing its ability to contain the radioactive steam and cooling water. NRC required all reactors with a torus containment to make extensive modifications designed to



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upgrade the integrity of the torus to better withstand potential accidents.

Other backfits imposed to remedy design deficiencies identified from operating experience include

- Fire protection modifications—The fire at the Tennessee Valley Authority's Browns Ferry plant in 1975 disclosed that problems existed with the measures for preventing and fighting fires inside nuclear plants. NRC issued a rule (a new regulation) in 1980 that specifies its fire protection requirements and has since been working with utilities to develop detailed plans for every nuclear power plant to upgrade its fire protection capabilities.
- Environmental qualification of electrical equipment—In the late 1970's NRC became concerned that the safety-related electrical equipment inside a reactor containment building would not continue to function in the hostile environment (high temperature, pressure, humidity, and radiation) that could exist after a serious accident. Consequently, starting in 1977, NRC's Office of Inspection and Enforcement issued a series of bulletins requiring all plants to have electrical equipment inside plant containment structures tested, or "environmentally-qualified", to ensure that the equipment will function as intended in a hostile environment. NRC subsequently developed new regulations on environmental qualification to formalize its position on this safety issue and is now in the process of working out implementation plans for each plant.

## Backfits Required to Upgrade Plant Safety Levels

Backfitting requirements may also arise from operating incidents that draw NRC's attention to the need for greater safety precautions than had previously been required. For example, after the accident at the Three Mile Island nuclear power plant, NRC developed extensive new requirements for all plants in operation or under construction. One requirement is that utilities must install post-accident sampling facilities in the plants that would provide an analysis of the reactor cooling water within 1 hour after an accident begins. The basis for this requirement is that during the Three Mile Island accident, the plant operators were unable to accurately determine the reactor's condition. One method for assessing the condition of the reactor is to sample and analyze the cooling water to determine the extent, if any, of damage to the nuclear fuel. High radiation levels at the Three Mile Island plant, however, prevented the operators from obtaining and analyzing such samples for several days. NRC

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determined that prompt collection and analysis of reactor coolant samples would have shown that significant core damage had occurred and allowed the correct remedial actions to be taken earlier.

Other examples of backfitting requirements of this type include

- Additional internal and external plant security systems— This requirement was the result of increased NRC concern over the possibility of terrorist attacks or sabotage. In 1977 NRC issued a new rule that required owners of all plants to increase security by limiting access to the plants and controlling the movement of employees within the plants.
- Emergency operations facilities—During the Three Mile Island accident, management of recovery from the accident and coordination of federal, state, and local emergency response actions was difficult. Subsequently, NRC required owners of all plants to construct emergency operations facilities away from their plant sites for the purpose of conducting these types of activities in the event of accidents at their plants.

## Problems Resulting From NRC's Past Backfitting Activities

NRC has imposed backfits to correct deficiencies in design, construction, and operations. There is widespread agreement that certain NRC backfitting requirements have been necessary to maintain adequate levels of plant safety, security, and environmental protection. NRC and industry officials pointed out several examples, such as the torus modifications in boiling water reactors and certain aspects of the fire protection improvements required at all nuclear plants, where changes were made to existing systems that clearly improved plant safety.

However, because of the historical lack of NRC management control of backfitting, not all of them have been equally effective in ensuring or improving plant safety. According to the report[2] of the Special Inquiry Group commissioned by NRC to investigate the accident at Three Mile Island,

"The present regulatory system is also characterized by substantial diffusion of responsibility and accountability. The present organization is fragmented, and little NRC attention has been given to the relationships of the various staff offices. Effective overall management controls are nonexistent, and the NRC's failure to provide general policy guidance fosters a system affording considerable amounts of unbound, and effectively

[2]Special Inquiry Group, Three Mile Island: A Report to the Commissioners and to the Public (Jan. 1980).



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unreviewed, discretion to the staff members who make the technical engineering judgments that ultimately determine the degree of safety to be required in a nuclear plant."

Another Three Mile Island accident investigative group, the President's Commission on the Accident at Three Mile Island, concluded that NRC did not usually systematically review, on a plant-by-plant basis, the new guidelines it provided to utilities.[3] Moreover, this commission found that "the major offices within the NRC operate independently with little evidence of exchange of information or experience". It also found that no office existed within NRC that was responsible for integrating overall plant design and performance or analyzing interaction between major plant systems.

These and other concerns led NRC to solicit utility views on its backfitting activities. In 1981 senior NRC staff officials at the office and division director level met with their counterparts at 12 utilities and reported to the Commission that it needed to take prompt action to bring the issuance of new requirements under control. This recommendation was based on input from the utility executives as well as on the working knowledge and experience of the NRC representatives.

NRC's recognition that it needed to better manage the imposition of new regulatory requirements on nuclear plants under construction and in operation was stated succinctly in response to questions raised in hearings on March 22 and June 8, 1983, before the Subcommittee on Energy Conservation and Power, House Committee on Energy and Commerce. In responding to questions on backfitting, NRC stated that, historically,

- no central point existed for controlling the nature and pace of new requirements,
- the effects on or the relative importance of each new requirement to overall plant safety had not been determined,
- costs and benefits of new requirements had not been determined in a uniform manner, and
- some NRC schedules for implementing backfits at nuclear power plants had not been established in an optimal manner.

This viewpoint was reinforced by a report prepared for DOE that concluded that NRC's backfitting procedures were unsystematic and out of

[3]Report of the President's Commission on the Accident at Three Mile Island (Oct. 1979).



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control.[4] The report recommended that NRC (1) clearly define backfits, (2) issue generally understood safety standards, and (3) develop clear backfitting guidance and criteria for the NRC staff and utilities.

Although the reasons why backfitting is sometimes necessary and the historical lack of effective NRC management control of backfitting are well recognized, the implications of ineffective management control are less clear. As discussed in the following section, we found examples of backfits that have resulted in questionable safety benefits and/or excessive costs.

## Questionable Safety Benefits Linked to Backfitting Activities

Although NRC's 1970 backfitting regulation states that backfits are required when they provide "substantial additional protection," some of NRC's past backfitting requirements have resulted in questionable safety benefits. Both utility and NRC officials stated that backfits have been imposed at plants that may not have resulted in safety improvements or may have had negative safety consequences. Further, concerns exist regarding the overall impact that backfitting has had on plant operations and safety.

### Concerns Over the Safety Benefits of Individual Backfits

Although NRC may have had valid reasons for examining the safety issues that eventually resulted in backfits, the agency (except in one case) did not perform analyses to determine the need for the backfit, the safety improvements to be obtained, or the difficulties facing utilities in performing the required actions. The burden of proof has been on utilities to convince NRC, where appropriate, that backfits were not needed. Three examples of backfits that have had questionable safety impacts are discussed below.

1. Water-level instrumentation—During the March 1979 Three Mile Island accident, plant operators interrupted the flow of emergency cooling water into the reactor, thereby allowing the nuclear fuel to become uncovered. Subsequently, in 1980 NRC required owners of pressurized water reactors to install instrumentation to accurately measure the level of water in the reactor. When NRC imposed the requirement through a NUREG document and letters to utilities, it did not know whether the backfit was technically feasible or how it would be implemented. Nevertheless, it required utilities to install the instrumentation by January

[4]International Energy Associates, Ltd., Analysis of Nuclear Backfitting Issues to Support Recommendations For Regulatory Reform (Aug. 1984).



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1982. Designing reliable water-level instrumentation has been a difficult problem for utilities. After 5 years of effort and costs as high as $7 million at one plant, this instrumentation is still not in use. After a comprehensive review of this issue in 1982, NRC's Executive Director for Operations concluded that substantial safety benefits would result from additional water-level instrumentation to detect inadequate cooling. There is widespread industry doubt, however, that this modification will enhance safety because, during most accident sequences, the information provided by the instrumentation could be confusing to plant operators. (See fig. 2.4 for a more detailed discussion of this requirement.)

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**Figure 2.4: Water-Level Instrumentation**

The accident at Three Mile Island in March 1979 was initiated when water escaped through a valve that had stuck open. The operators misinterpreted their instruments and interrupted the flow of emergency cooling water into the reactor, thereby allowing the level of water in the reactor to drop and uncover the hot nuclear fuel.

In its review of the accident, NRC determined that additional instrumentation showing how much cooling water was in the reactor might have prevented the operator errors. Shortly after the accident NRC required all utilities with reactors similar to the one at Three Mile Island to design, procure, and install instrumentation by January 1982 to accurately indicate the status of the cooling water.

Implementation of this backfit has proved difficult. The requirement was issued before NRC had done any detailed technical analysis, and it was not clear at that time whether such instrumentation could be developed or how long it would take to install and operate the new systems. According to NRC records, two utilities designed and installed the system by the required date, but one utility's system was rejected by NRC. By the end of 1983, 21 of the 53 pressurized water reactors that had to meet this requirement had installed this backfit, but none of the systems were in use. Further, two utilities have experienced leaks attributable to this new equipment that have caused additional safety concerns.

Many questions have been raised about the need and schedule for this requirement. Utilities are concerned that adding more instrumentation will not address the problem, which is that plant operators were overwhelmed with data during the accident at Three Mile Island. Utilities also point out that the instrumentation, as designed and installed, will not provide a direct reading of the water level in the reactor; therefore, it may provide erroneous or misleading information. The ACRS, an independent regulatory advisory committee to NRC, also expressed concern that the instrumentation might provide anomalous or misleading information. As stated by two members of that committee, "We . . . are concerned about the proliferation of inadequately considered requirements, of which this is only one example. To sanctify an ambiguous indication of core water level is to play with fire."

2. Diesel testing requirements—In a nuclear power plant, a number of critical safety functions, such as cooling and monitoring the nuclear fuel, depend on the continuous supply of electricity. Because of safety concerns regarding the potential loss of electricity, nuclear power plants are



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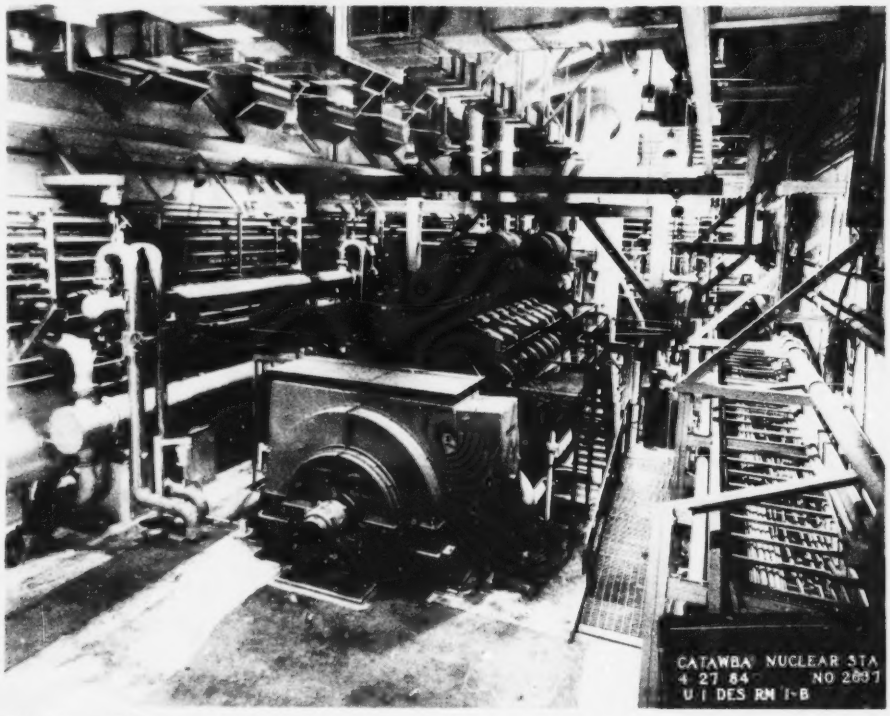
required to have diesel generators to provide electricity to critical systems in the event that backup off-site power is lost. Figure 2.5 shows a 10,000 horsepower nuclear plant diesel generator.

**Figure 2.5: Emergency Diesel Generator**




Duke Power Co.

The diesel generator in figure 2.5 is one of two identical generators at Duke Power's Catawba 1 station. These units are not used during normal operations, but may be needed to supply electrical power to safety equipment and the reactor in the event that all off-site sources of electricity are lost. Since electrical power is so critical to the safe shutdown and monitoring of a reactor, most plants have more than one diesel generator. Diesel generators are large and complex machines, requiring special sophisticated systems for lubrication, cooling, and operation.

Prior to 1977 utilities were only required to start their diesel generators once each month, with no specific goal for reliability. In August 1977, however, NRC issued a regulatory guide that outlined schedules and procedures to test this equipment. The guidelines required that the diesels

be started and brought up to full power within 10 seconds. This is analogous to starting an automobile and immediately driving it at highway speeds. If the diesels failed to achieve full power within the required time more than one time in 100 tests, the diesels had to be tested every 2 weeks; if those tests resulted in failures, weekly testing was required; the guidelines required testing every 3 days if the diesels failed the weekly tests. According to the branch chief responsible for diesel testing requirements, this testing regimen was based on generally accepted statistical projections of reliability that did not take into account generally accepted engineering practices pertaining to the use of large diesel generators. He also stated that some utilities interpreted the requirement to mean that the diesels had to be started "cold," without warm-up, because NRC had not specifically stipulated the required pre-start condition of the diesels. According to NRC technical staff, "cold" start-up would only be necessary in the remote possibility that off-site power is lost at the same time a large break occurs in the reactor's cooling system.

This testing requirement has resulted in increased wear and mechanical damage to the emergency diesel equipment. Both utility and NRC officials we interviewed stated that this testing requirement may actually reduce, rather than ensure, the reliability of the diesels. In August 1983 an NRC technical review committee stated that "there is a need to rectify those existing test and surveillance requirements that are known to be causing wear-out of diesel generator equipment. The overall effect of these requirements is to degrade safety, the diesel generator reliability, and plant availability. . . ." "The nature of the tests being required is not properly focused on those more probable demands expected of the diesel generators . . . where the need for fast starting and loading is substantially diminished." The NRC technical staff responsible for developing this requirement is currently working to develop a revised testing program that would identify unreliable diesel generators while placing less stress on this equipment.

3. Boron dilution monitors—The NRC staff required the installation of instruments to monitor boron levels in the reactor coolant of two reactors applying for operating licenses. Boron is a chemical used to control the nuclear reaction and to help ensure that the reactor is in a safe condition while it is not in operation. Since NRC was concerned that the boron levels could become diluted and the reactor could spontaneously restart while shut down, instruments to measure boron levels have been installed at a cost of about $100,000 per plant. However, in December



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1984 NRC concluded in a report on generic safety issues[5] that potential plant incidents related to boron dilution ". . . did not constitute a significant risk to the public."

Senior NRC officials agree that some backfits were imposed that were not fully justified in terms of improved safety. The Chairman of NRC's Regulatory Reform Task Force, which was established by the Commission to assess NRC regulatory practices and their impacts, and recommend improvements, stated that certain requirements imposed by NRC have been marginal or "nice to have" changes but were not necessary for improving overall plant safety. He added that because of the lack of a disciplined approach to backfitting, the NRC staff did not have to demonstrate that these types of backfits were needed before imposing them; consequently, they were imposed without demonstrated safety benefits. Officials in the Office of the Executive Director for Operations also stated that backfits, particularly some of the Three Mile Island-related requirements, have had questionable need.

## Backfitting May Have Adversely Affected Overall Plant Safety

Backfits are imposed to resolve specific safety problems, yet they may also affect other plant safety systems. Consequently, the imposition of new backfitting requirements can raise other safety issues. NRC has recognized that its backfitting activities, from an integrated plant safety perspective, may have had some negative consequences. NRC's August 1981 survey report on utility views of the safety impact of regulatory activities concluded ". . . that the pace and nature of regulatory actions have created a potential safety problem of unknown dimensions" in part stemming from inadequate NRC evaluation of the impact of many changes at individual plants on other safety-related plant activities.

Officials we interviewed at the senior management level of the nuclear industry agreed with NRC's conclusion and asserted that NRC's historical approach to backfitting nuclear power plants with numerous new regulatory requirements may have diminished the overall safety of plants. According to these officials, when imposing backfits NRC has not considered factors affecting overall plant safety such as the following:

- Backfits have an impact on other plant systems or on the overall operation of the plant. In some cases, a change in one plant system can affect

[5]Generic safety issues are possible deficiencies in the design, construction, and operation of several or the class of nuclear power plants such that the protection of the public or the environment from radiation may be inadequate.



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other systems in unanticipated ways. For example, NRC's 1977 rule on security modifications to protect plants from sabotage required utilities to add controlled-access doors and personnel identification systems to restrict movement into sensitive areas of their plants. Although these modifications have increased security, they have also made some areas less accessible for routine operational activities, such as inspection and maintenance, and emergency operations, such as fire control.

- Backfits may increase plant complexity. Nuclear reactors have become increasingly complex as safety systems have been added and upgraded, making it more difficult to maintain and operate the plants. For example, structural supports on pipes have reduced access to areas in which inspection and maintenance activities must be conducted.
- Problems may arise from installation of backfits. The process of installing a backfit can create new safety concerns. For example, two utilities we visited pointed out that NRC's requirement for water-level instrumentation required drilling new holes into the reactor piping and installing as much as 200 feet of piping in the plant. Leaks have occurred that resulted in a 10-day outage at one plant.

## Backfitting Practices Have Added to Plant Costs

Although the costs of backfitting are not fully known, the direct cost of backfitting on reactors currently operating may have totaled nearly $5 billion through 1982 (see p. 27). Most of these past costs have been necessary to install the backfits required by NRC; however, portions of these direct costs also have resulted from

- confusion over requirements,
- changes to requirements, and
- inappropriate time frames for completing requirements.

In addition, utilities have also incurred indirect backfitting costs. NRC officials from various offices agreed that the volume of NRC's past backfitting requirements and the methods by which some backfits were imposed have resulted in the following types of costs and burdens on utilities.

### Confusion Over Requirements

Because of the various NRC methods and staff offices involved in imposing new requirements on plants, there have been varying interpretations among NRC staff and utilities regarding what requirements must be met. NRC staff send utilities many documents, such as notices from the Office of Inspection and Enforcement and published NUREG documents, to disseminate information derived from operating experience at other plants,



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offer advice on potential safety problems, and suggest actions that could be taken.

We identified instances, however, in which the NRC staff used this guidance to impose new requirements or to encourage utilities to make changes at their plants that the agency was not requiring plant owners to make. For example, one utility representative we interviewed stated that NRC staff directed his company to follow the provisions of a NUREG document that provides utility guidance for developing and implementing radiological emergency response plans and installing computer systems to monitor radiation exposure. According to the official, the NRC staff strongly encouraged the utility to conform to the guidance in the document. Subsequently, however, NRC did not require other utilities to install similar systems. The utility installed the computer system at a cost of $2 million, but the system was eventually found to be unreliable and is not currently used.

Utility representatives acknowledge that they do not have to agree to perform all NRC-recommended actions that are not explicitly identified as requirements, or to perform them in the way that the NRC staff directs. They point out, however, that a company that does not cooperate fully with NRC may give the appearance of not strongly promoting plant safety. Additionally, backfitting requirements are usually imposed when a utility is either seeking its initial plant operating license or is attempting to restart operations after being shut down for refueling, maintenance, and plant modifications. Therefore, the representatives said, the additional time that may be required to contest and resolve proposed new regulatory requirements can subject their plants to costly delays in start-up. Because of the high cost of an idle nuclear power plant, they said, it is usually less expensive to accept backfits than to contest them while their plants remain idle. For this reason, they said, they are inclined to agree to backfits so as not to jeopardize obtaining a timely operating license or permission to restart their plants. NRC officials such as the Chairman of the CRGR and the Regulatory Reform Task Force agreed that this situation existed and was used to encourage utilities to accept backfits proposed by the NRC staff.

Utility officials added that the lack of clarity in what constitutes "guidance" versus an NRC regulatory requirement causes additional difficulties in hearings before state public utility commissions. Some state utility commissions are examining nuclear power plant costs in more

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detail than they have in the past and are only allowing costs explicitly required by NRC to be passed on to electricity consumers.

### Changes to Requirements

Utilities have been encouraged or required by the NRC staff to implement backfits before NRC would grant official approval of the modification. In some cases NRC has changed its requirements or its interpretation of existing requirements, commonly referred to as "backfits to backfits," making it necessary for the utility to perform additional changes and resulting in higher costs. Such changes have occurred in the area of fire protection, as discussed in figure 2.1.

Another example frequently noted by utilities is NRC's changes to emergency operations facilities. (See figs. 1.1 and 1.2.) The purpose of the facilities is to provide locations away from plants where federal, state, and local officials can monitor the corrective actions being taken during any nuclear plant emergency and coordinate emergency response activities. In September 1979 NRC required that the emergency facility be operational by January 1981. NRC provided further guidance in January 1980 that it be located within 1 mile of the plant. In November 1980, however, NRC revised this criteria and issued another document requiring that emergency operations facilities be constructed more than 5 miles from plants. Two utilities we contacted stated that they had completed their facilities before NRC's initial January 1981 deadline. Because of the revised criteria, however, they now have to modify the building by adding new materials to reduce potential post-accident radiation levels in lieu of building new facilities at the required distance. These modifications are expected to cost $2 million to $3 million at each plant. Another utility that built its facility within 1 mile of the plant is currently contesting NRC's revised requirement that it construct a backup facility farther away.

### Arbitrary and Inappropriate Time Frames

In the past NRC has not fully considered the effects of backfits on utilities and their plant operations. When imposing backfits, NRC did not consider the utilities' installation problems or their ability to perform the backfits in the time frames required by NRC. As a result, unrealistic time frames have been imposed in some cases. In particular, the deadlines NRC initially established for many of the Three Mile Island-related requirements were established before the equipment and systems needed for the backfits had been developed. Water-level instrumentation (see fig. 2.4) is one such example. This is also an example of backfitting that NRC required of utilities before it would approve the utilities'


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methods for meeting the requirement. Utility officials stated that this type of backfit puts them in financial jeopardy because they have to expend funds on actions that NRC may not approve.

## Indirect Backfitting Costs

Nuclear industry officials point out that an area of backfitting costs that is not taken into account in many discussions of backfitting is indirect costs. They stated that there are a number of costs that are not identifiable as a direct expense resulting from new regulatory requirements. These indirect costs of backfitting include, but are not limited to the following:

- Engineering and other plant staff has been expanded to manage the design, procurement, and installation of backfitting requirements. Utility representatives stated that personnel costs have increased and, in contrast with the one-time cost to install a hardware change, result in recurring expenses. Data provided to NRC from utilities indicates that the size of plant staffs has doubled or tripled since the Three Mile Island accident.
- Plants have had to add space to accommodate backfitting. At a 3-unit plant, a new $65 million structure had to be built to create an alternative capability to shut the plant down in addition to the systems that had originally been included in the plant. According to the utility, this had to be done to meet new NRC security, fire protection, and flood protection requirements. Utilities have also had to expand facilities at their plants to accommodate larger staffs. One utility, for example, spent at least $11 million on expanded facilities at its plant. Another plant we visited was in the process of constructing a new administration building and plant staff were being located in a temporary inflatable structure while the new facility was being built. According to utility officials, the new building was needed because additional utility staff, which were not anticipated when the plant was built, were required to manage the increasing volume of backfits at the plant.
- Utility repair and maintenance schedules have been expanded or delayed. Most backfits to operating plants are installed during refueling outages. Utility officials that we interviewed stated that these outages were originally expected to last 4 to 6 weeks but now routinely take 3 to 4 months to accommodate backfits performed in conjunction with refueling. Replacement power needed to meet consumer demand must be produced by other facilities within the utility system or purchased from other utilities while the generating equipment that is taken out of service is modified. One utility reported that its plant was shut down for 6



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months to install a required backfit, and replacement power costs of more than $260,000 per day were passed on to the consumers.

- Workers have had additional exposure to radiation. Several backfits, such as torus modifications and modifications to ensure that plant piping systems can withstand earthquakes, involve working on equipment or structures located in high-radiation areas. The maintenance and inspection of these backfits causes workers to be subjected to radiation. Consequently, although worker exposure is monitored and efforts are made to prevent individual over-exposures, the cumulative amount of exposure to radiation for the entire work force is increased.

Utility officials we contacted could not quantify the indirect costs of backfitting; however, they all stated that these costs are significant. One utility official estimated, in a letter to NRC's Regulatory Reform Task Force, that the indirect costs of backfitting at the utility's plant were at least equal to the direct costs.



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# NRC Has Improved Backfitting Management but Problems Remain

NRC has taken actions to improve the way it manages backfitting of new requirements on nuclear power plants. They include new processes for documenting and reviewing backfits and a system to help utilities integrate backfits with other plant activities. Through these steps NRC has begun to establish management control over backfitting. As of April 1985, however, NRC was still not making explicit determinations that proposed new regulatory requirements provided "substantial additional protection" before imposing them on nuclear power plants under construction or in operation. In addition, the NRC staff did not always prepare all of the analyses and documentation required to support backfitting determinations. Finally, the NRC staff was still imposing backfits outside of the established management control processes.

In recent months NRC issued a new backfitting regulation and began strengthening its procedures for managing backfits that apply to a single plant or all plants at a single location. These measures, in conjunction with earlier backfitting management initiatives, should largely provide a framework for an effective backfitting management system. NRC now must focus its attention on assessing the NRC staff's implementation of the system.

## NRC Backfitting Initiatives

Beginning in late 1981 NRC took steps intended to improve its management of backfitting. It has separated backfits into two types—generic and plant-specific. Generic backfits involve regulatory requirements that apply to all plants or groups of plants having certain characteristics. For example, backfits that apply to all pressurized water reactors (a type of reactor that operates under high pressure to prevent the boiling of water in the reactor), all reactors of a certain manufacturer, or all plants that use piping made by a specific fabricator are all generic backfits. Plant-specific backfits involve regulatory requirements that apply only to a specific plant or to identical plants at one site. NRC has instituted review processes for each type of backfit intended to control the number and nature of the requirements being imposed, eliminate or remove unnecessary burdens placed on utilities, reduce the exposure of workers to radiation when implementing requirements, and ensure that NRC and utility resources are assigned to the highest priority safety improvements. Additionally, NRC has established a system to facilitate utility management of backfits in conjunction with utility-initiated plant activities and has proposed changes to its backfitting regulation.

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## Generic Backfitting Review Process

Because the regulatory requirements that provide the basis for each generic backfit apply to all or a group of nuclear power plants, they represent the major part of all NRC backfitting activities. To better control backfitting of new generic regulatory requirements, the Commission directed the establishment of the CRGR in October 1981. The CRGR was assigned responsibility for reviewing all proposed generic backfitting requirements to ensure that they effectively contribute to the protection of public health and safety before they are imposed on utilities constructing and operating nuclear power plants. In conjunction, the NRC staff has been directed by the Executive Director for Operations to submit proposed generic requirements to the CRGR for review.

The CRGR is chaired by NRC's Deputy Executive Director for Regional Operations and Generic Requirements and is comprised of six members from various offices within NRC. Its original charter charged it with reviewing all proposed generic documents that would transmit new requirements to nuclear power plants and recommending approval or disapproval of these requirements to the Executive Director for Operations. NRC subsequently modified the charter, however, to require CRGR review of generic documents forwarded to it by staff offices. These include proposed rules, orders, and staff requirements, such as regulatory guides, branch technical positions, and NUREG documents. In reviewing proposed generic requirements, the CRGR is required to evaluate each proposed requirement for its backfitting implications. The CRGR requires that each proposed new regulatory requirement that the NRC staff plans to backfit on nuclear plants under construction or in operation include (1) an assessment of the reduction in risk achievable from the proposed backfit, (2) an analysis of estimated costs to NRC and utilities, including occupational radiation exposure and increased plant complexity, as well as financial impacts, (3) a justification of the proposed backfit's implementation schedule, and (4) a prioritization of the proposed requirement in light of all other safety-related activities that need to be performed at the affected power plants.

The first meeting of the CRGR was held on November 12, 1981. Since then it has met 71 times through December 1984 and, according to information compiled by the CRGR staff, has reviewed 103 generic items. The CRGR has recommended

- approval of 12 items without modification,
- approval of 55 items after they were modified to address concerns raised by the CRGR, and
- disapproval of 7 items.



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In addition, the CRGR returned 10 items that were still pending at the end of our review to the NRC staff for additional work. Finally, the remaining 19 items did not require CRGR recommendations for approval or disapproval.

The CRGR Chairman believes that the committee has been effective in ensuring that proposed generic backfitting requirements receive consistent technical review before implementation. He pointed out that the CRGR review has resulted in better focus and justification for generic backfitting actions. The questions asked by the CRGR—involving safety, cost, and additional worker exposure to radiation attributable to the backfit—have required the NRC staff to better justify generic backfits and more thoroughly consider their impacts on utilities. The CRGR Chairman does not believe it has hindered actions that were needed to increase or maintain plant safety; instead he believes that the CRGR has prevented the imposition of proposed backfitting actions that would not have improved plant safety and were therefore unwarranted, such as the following actions:

- NRC technical staff proposed a backfit requiring utilities to modify certain types of valves, which could have ultimately resulted in reduced plant safety. The proposed modification would have replaced certain valve components with others that are more reliable in an accident. However, the new components were subject to other problems and would have caused the valves to be less reliable during normal plant operations. Consequently, according to CRGR staff, plants are safer during normal operation without this requirement.
- NRC also proposed a redundant requirement that utilities reinspect and reanalyze piping supports. The CRGR Chairman said that in this instance, the NRC staff that proposed the new requirement was not aware that NRC had already required utilities to inspect and, as appropriate, modify piping supports at their plants. If implemented, the proposed requirement would have caused utilities to unnecessarily reverify work that had already been performed.

The Commission and the utility industry generally view the CRGR as an improvement in NRC's process for imposing new generic backfitting requirements. The Commission has stated that it believes the CRGR provides an effective means for managing these new requirements. Industry representatives we contacted at utilities and the Atomic Industrial Forum stated that the CRGR has helped to prevent the imposition of unnecessary new requirements and has added discipline and control to NRC's generic backfitting activities.

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## Plant-Specific Backfitting Process

Each nuclear power plant is built to meet the utility's specific needs and therefore contains some features that are unique to that plant. Consequently, even plants of the same type can have different plant-specific characteristics. Further, the varying locations of the plants raise site-specific concerns, such as earthquake protection, that require plant-specific design measures. Plant-specific backfits, therefore, refer to new regulatory requirements that NRC believes are needed only at a certain plant, or at multiple units of the same design at one location, to resolve problems that are specific to that plant or site.

Because plant-specific backfits are not under the purview of the CRGR, the Commission, in a June 22, 1983, memorandum to the NRC Executive Director for Operations, required the NRC staff to prepare a plan for implementing procedures and requirements to manage plant-specific backfits. On August 5, 1983, the Executive Director for Operations submitted a proposed plan to the Commission and it was adopted on October 25, 1983.

The plant-specific backfitting process is intended to ensure that requirements imposed on operating nuclear power plants are justified, that the justifications are documented, and that senior NRC management is responsible for the implementation of this process. To this end, the plant-specific backfitting system

- requires the NRC staff to identify any new plant-specific requirement and briefly describe in a memorandum to mid-level NRC staff management how it would improve safety before it is imposed,
- provides utilities with an appeal process so they can request NRC officials up to the office director level to modify or withdraw the proposed requirement if they disagree with NRC's basis for imposing it, and
- stipulates that the NRC staff will perform a cost-benefit analysis of the proposed requirement if requested by the utility after the use of the appeal process.

The plant-specific backfitting process also requires the NRC staff to maintain records of backfits. Plant-specific backfitting processes have been established in the Office of Nuclear Reactor Regulation (for matters dealing with licensing requirements) and in the Office of Inspection and Enforcement (for issues related to plant inspections and subsequent enforcement action). NRC officials in the former office's Division of Licensing, which monitors plant-specific backfitting, stated that they have found the plant-specific backfitting process to be effective in identifying and documenting new plant-specific backfits and added that this


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procedure is being used to control backfits on new plants seeking their operating licenses as well as plants already in operation. NRC's records showed a total of 34 plant-specific backfits imposed from October 1983 through October 1984. Of these, 14 related to operating plant issues and 20 related to plants applying for their operating licenses.

## Integrating Backfits With Other Plant Activities

A major operational problem for utilities has been the integration of new NRC requirements with their own operating schedules and maintenance plans that must be met at each plant. To relieve this problem and provide more stability in accommodating its requirements, in May 1983 NRC and one nuclear plant—the Duane Arnold Energy Center, located near Cedar Rapids, Iowa—developed the first integrated schedule of plant modifications, commonly known as a "living schedule". The schedule integrates the utility's needs with NRC's requirements on the basis of a constant level of utility staffing and resources. It also details when various maintenance, retrofitting and refueling activities will be performed over a 5-year period.

The Pilgrim plant near Plymouth, Massachusetts, has also developed a living schedule, and other utilities are in the process of developing these schedules with NRC to guide their power plant backfitting activities. Schedules for performing NRC requirements are agreed upon between NRC and utility staffs. Adjustments to the schedules are agreed upon every 6 months to reflect any changes in NRC's backfitting priorities or utility needs. According to NRC, the living schedule provides the utility with realistic and enforceable backfitting implementation schedules.

## Management Weaknesses Remain Despite NRC Improvements

NRC's backfitting initiatives are intended to ensure that backfits are necessary to improve or maintain the safety of nuclear power plants. NRC has recognized that to provide this assurance, it needs a disciplined process for imposing the requirements that provides thorough and documented analyses justifying the backfits before they are imposed. Although the new backfitting processes and practices have resulted in some improvements, fundamental problems remain. NRC staff have not always complied with the new processes, particularly when requiring plant-specific backfitting actions. As a result, the desired control over backfits has not been achieved, and staff justifications of backfitting actions have not been complete. Further, NRC was still not using its backfitting regulation as its basis for imposing backfits.

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## Control Over Backfits Not Yet Achieved

NRC has recognized that it needs to have central review and control of all proposed requirements, and acknowledged this in written responses to questions raised during hearings on March 22 and June 8, 1983, before the Subcommittee on Energy Conservation and Power, House Committee on Energy and Commerce. At that time NRC stated that problems existed with its backfitting policies and procedures because "... there was no central point for controlling the nature and pace of new requirements."

NRC believed that the establishment of the CRGR remedied this problem; we found, however, that the desired central control of backfitting has not been established. New generic requirements were still being imposed upon nuclear power plants using the plant-specific backfitting process. Consequently, they were not reviewed by the CRGR. Further, backfits were still being imposed outside the procedures prescribed in the generic and plant-specific backfitting processes.

### Plant-Specific Process Used to Impose Generic Requirements

Although the plant-specific backfitting process is to be used to impose requirements that apply to only one plant or plant site, NRC staff have been using this process as a method for imposing new requirements on utilities that are applicable to plants at more than one site and, therefore, fit NRC's definition of generic requirements. We reviewed documents relating to the 25 backfits that utilities and the NRC staff identified between October 1983 and October 1984 as plant-specific backfits. We found that about one-third of these backfits imposed new requirements that applied to several plants at different locations, and others contained new staff interpretations of generic issues. For example,

- The NRC staff required utilities seeking operating licenses for the Nine Mile Point Unit 2 (New York) and Beaver Valley Unit 2 (Pennsylvania) plants to use new probable maximum precipitation estimates, contained in two National Oceanic and Atmospheric Administration reports published in 1982, to calculate the maximum flood levels that the plants have to be built to withstand. Both utilities objected to the requirement because it differs from the precipitation estimates referenced in NRC's Standard Review Plan—the guidance that the NRC staff had used to evaluate the two utilities' plant construction permit applications. The NRC staff required the utilities to use the more recent precipitation estimates without prior CRGR review. It justified this action by stating that when reviewing plant safety, new or updated reference material, such as the two new reports, may be used without being submitted for CRGR review. The NRC staff also required utilities building three other plants



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to use the precipitation estimates contained in the two recent reports. (See fig. 3.1 for a detailed discussion of this requirement.) According to the CRGR charter, however, any change to the Standard Review Plan is supposed to be reviewed by the CRGR before it is imposed on a utility.

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**Figure 3.1: The Development and Debate Over a Proposed Change to Precipitation and Flood-Protection Calculations**

One provision of the NRC Standard Review Plan is for utility analysis of potential flooding at the plant site and protection against projected flood levels. It directs utilities to use National Oceanic and Atmospheric Administration Hydrometeorological (HMR) Report No. 33 (published in 1956) for estimating the probable maximum precipitation at the plant site and for calculating the maximum potential flood levels resulting from rainfall.

Six plants that have recently been completed, or are nearing completion, submitted precipitation estimate calculations to NRC based on HMR 33. However, NRC staff began to require the plants to meet the estimates contained in two more recent reports, HMR 51, dated June 1978, and HMR 52, dated August 1982. The more recent estimates are higher than HMR 33. For example, at one plant—the Catawba Nuclear Station (South Carolina)—the estimates for the probable maximum rainfall increased from 11 inches per hour to 19 inches per hour. The other five affected plants include Nine Mile Point 2 (New York), Beaver Valley 2 (Pennsylvania), Hope Creek (New Jersey), Shearon Harris (North Carolina), and Millstone 3 (Connecticut). Three of these plants stand beside plants licensed to operate that do not have to meet the new requirements but would be subject to the same rainfall.

The affected utilities view the NRC staff's use of HMR 51 and 52 as a generic backfit because it is a change in the Standard Review Plan. In their view, the precipitation estimates in the two new reports are far too restrictive. Catawba officials said that the highest recorded rainfall near their plant was 20 inches in a 24-hour period, which equates to a rate that is less than the new estimate of 19 inches in one hour.

The NRC staff do not believe their use of the new estimates is a generic backfit. Since the Standard Review Plan allows the use of new calculational methods, the NRC staff view their actions as complying with the Plan. The staff identified this requirement as a plant-specific backfit at Nine Mile Point 2 and at Beaver Valley 2. In the other four cases, the staff achieved utility cooperation or are currently discussing the requirement and its implications with the utility. They have not, however, identified this change as a plant-specific backfit at the four plants.

The Chairman of the CRGR notified the staff in May and August 1984 that the revised precipitation estimates appear to be a new generic requirement subject to CRGR review. Although the NRC staff are now preparing a regulatory analysis and justification to be reviewed by the CRGR on this issue, they are still attempting to require new plants to use the revised estimates when applying for an operating license.

- NRC is currently requiring the Beaver Valley Unit 2 plant to install a fire-suppression system that uses water in the area in the plant through which the thousands of electrical cables used in the plant are routed.



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NRC is requiring this system to provide backup to the installed gas (carbon dioxide) fire-suppression system. The position of the NRC staff reviewing the utility's application for an operating license is that the gas fire-suppression system currently installed is not in conformance with NRC's Standard Review Plan. However, neither the Standard Review Plan nor other related NRC requirements mandate the use of water-based systems. Further, the plant's gas fire-suppression system is similar to that in use at eight operating plants. Because the Standard Review Plan applies to all nuclear power plants, we believe this example represents a generic rather than a plant-specific requirement.

- NRC staff are requiring the Shoreham plant in New York to develop a procedure to determine the type and magnitude of cladding (hollow rods that contain nuclear fuel) failures or core melt-downs. If these failures occurred, radioactive gases or materials could contaminate the cooling water and other portions of the power plant. The staff want the utility to be able to determine, in an accident situation, the extent of cladding failures and/or core melt-downs from a sample of reactor cooling water. According to NRC's project manager for this plant, this requirement is based on a recommendation of the NRC Special Inquiry Group report on the Three Mile Island accident, and not on any explicit regulatory requirement or any feature specific to the plant. According to NRC documents, this requirement has also been imposed on other plants; therefore, we believe it is a generic requirement subject to review under NRC's generic backfitting process.

Other backfits we examined that were imposed using the plant-specific process had generic implications because they dealt with changes in the NRC staff's interpretation of generic requirements such as NRC's fire protection measures, the Three Mile Island Action Plan, or the Standard Review Plan. For example, one backfit required an operating plant to reanalyze its auxiliary feedwater systems. However, the NRC staff's basis for the requirement is the Standard Review Plan, which NRC does not officially apply to operating plants. Further, NRC is considering a generic requirement on this issue for operating plants. Consequently, this issue is a generic item, and imposing it through the plant-specific backfitting process does not appear appropriate.

The NRC staff generally do not agree that they are imposing generic backfits using the plant-specific process. For example, NRC technical staff officials responsible for reviewing flood protection at plants stated that the staff are simply measuring utility plans against the most current data available. They do not consider the requirement that utilities use the 1982 precipitation reports as a change in NRC's regulatory

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requirements. Further, NRC officials monitoring plant-specific backfits stated that the staff believe plant-specific backfits are generally attempts to achieve utility compliance with existing regulations, and not efforts to impose new standards.

Utility officials we contacted, however, stated that the plant-specific backfitting process has become a method used by the NRC staff to avoid CRGR review of what are really new generic requirements. They stated that most plant-specific backfitting requirements are the result of new interpretations of previous NRC positions and represent an effort by the NRC staff to impose new generic requirements on individual plants. They pointed out that NRC has historically used this strategy to impose new generic requirements on a plant-by-plant basis until all plants comply, particularly on plants applying for an operating license. Since utilities are anxious to begin operating their new plants as soon as possible, they maintain that the NRC staff attempt to impose generic requirements on these plants using the plant-specific backfitting process. Finally, they stated that utilities are reluctant to contest these generic requirements for fear that NRC will not award operating licenses for their new plants in a timely manner.

Senior NRC management officials acknowledged that they have become more aware of this problem and cited one case—the Beaver Valley Unit 2 plant, which is nearing construction completion—where the Executive Director for Operations asked the NRC staff to provide their justification for imposing requirements on that plant. The CRGR staff also stated that recognition exists within NRC that the management controls over backfitting that NRC has established have not been entirely successful because NRC staff continue to impose new regulatory requirements without the required backfitting reviews.

## The NRC Staff Continued to Impose Backfits Outside the Established Processes

NRC's generic and plant-specific backfitting procedures are intended to prevent the backfitting of nuclear power plants without the oversight and approval of senior NRC management. NRC recognized the problems resulting from uncontrolled backfitting and created these backfitting procedures as a means of controlling the number and nature of new requirements placed on power plants.

However, the NRC staff continued to impose new generic and plant-specific requirements that had not been reviewed in accordance with the provisions of each process. For example,



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- Generic letters, one method of transmitting new generic requirements to utilities, may have imposed backfitting requirements without CRGR review. During fiscal years 1983 and 1984, 63 of these letters were issued, but neither NRC staff responsible for issuing these letters nor CRGR staff could provide documentation showing which had received CRGR review. Although they could not provide a precise number, CRGR staff stated that many of the letters contained new generic requirements but had not been sent to the CRGR for review.
- NRC staff informally imposed a new requirement on one plant that had previously been disapproved twice by the CRGR as an unnecessary generic requirement. In this instance the staff required the plant to provide new information and acceptance criteria for instrument set-points (components designed to automatically initiate appropriate safety systems to ensure that fuel design limits are not exceeded and to sense accident conditions). CRGR meeting minutes showed that this additional requirement was discussed as a generic issue and that the committee was concerned that this could have negative safety impacts. The Director of NRC's Office of Nuclear Reactor Regulation did not personally review and approve the imposition of this requirement on the plant. Subsequently, the Director noted in a memorandum that he does not agree that this is a backfit, but added that the staff's review of set-points may be beyond what is needed to provide adequate assurance that plants operate as designed.

The problems of the staff not following the established backfitting process appear particularly acute on plants applying for operating licenses. Officials from one utility we visited stated that the NRC staff are not identifying backfits and having them approved by NRC management before they are imposed on these plants, and that only when utilities complain about a requirement will NRC staff initiate any action to justify their position. Representatives of Duquesne Light Company, located in Pittsburgh, Pennsylvania, pointed out 15 requirements that have been imposed on their Beaver Valley Unit 2, which is currently under construction and NRC operating license review. The utility viewed each requirement as a backfit, and in each case the utility contended that the NRC staff did not use the required generic or plant-specific backfitting management process to identify, document, and control these backfits. Consequently, the utility requested that NRC use its backfitting process. At the time of our review, discussions were still underway between NRC and the utility to determine how these requirements would be handled.

NRC staff correspondence related to the Beaver Valley Unit 2 requirements states that the responsible NRC staff view these issues to be



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related more to the resolution of their safety-related questions—part of their normal regulatory responsibility to ensure that plants can operate safely—than the imposition of new regulatory requirements that would be subject to NRC's backfitting procedures. The Chairman of NRC's Regulatory Reform Task Force, however, stated in his March 1985 report on backfitting that the Beaver Valley Unit 2 requirements are clearly examples of backfits that should be subjected to NRC management review.

Senior NRC officials stated that there are problems with the technical staff adhering to the backfitting procedures before imposing the backfits. The Chairman of NRC's Regulatory Reform Task Force stated that the NRC staff's use of informal mechanisms to impose backfits "is firmly ingrained in the regulatory culture." CRGR staff stated that the technical staff often have a narrow view of what is a backfit and that there is a staff reluctance to change past practices.

NRC's Office of the Inspector and Auditor also noted these problems in 1984 and 1985 audit reports on generic and plant-specific backfitting management.

The Office's March 1984 audit report on the performance of the CRGR stated that the NRC technical staff had imposed at least 16 generic issues on utilities that did not receive the required CRGR review prior to utility notification of the new requirements. CRGR staff stated that they have realized that there are problems in this area and that, with regard to generic backfits, they periodically monitor documents not reviewed by the CRGR to ensure that they do not contain new generic requirements. One official said, for example, that information notices issued by the Office of Inspection and Enforcement occasionally become prescriptive—instead of simply informative—and is an area they watch closely.

The CRGR staff pointed out that although the original CRGR charter specified that all generic documents were to be reviewed by the CRGR, NRC subsequently modified the charter to require CRGR review of generic documents forwarded to it by NRC staff offices. According to the CRGR staff, this modification prevents the CRGR from ensuring that all new generic regulatory requirements receive CRGR review before they are imposed on nuclear power plants. They added that because these documents do not have to be signed or approved by the Executive Director for Operations, new requirements can be issued without CRGR knowledge of the proposed actions. They also pointed out that the NRC technical staff have been directed to send new generic requirements to the CRGR by (1) the



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Executive Director for Operations, (2) the CRGR charter, and (3) internal office guidance letters, but the NRC staff have not complied with these directives. The CRGR staff added that they attempt to monitor compliance with the CRGR review procedures, but the modified CRGR charter does not provide an effective remedy to prevent NRC staff from issuing new requirements without CRGR review.

In commenting on our report, NRC provided us with a June 1985 NRC Office of Inspector and Auditor report on the agency's management of plant-specific backfitting under the agency's October 1983 plant-specific backfitting management procedures. The report analyzed 22 new or revised regulatory requirements tracked as backfits by the Office of Nuclear Reactor Regulation that were based on NRC staff positions contained in various NRC documents. The office found that the requirements had been originally identified as backfits by utilities only after NRC had sought to impose them on utilities' plants. None of the requirements had been identified by the NRC staff as potential plant-specific backfits or processed in accordance with the plant-specific backfitting procedures before the staff imposed the requirements on utilities. In its report the Office concluded that the backfitting procedures were not adequate and that "... the effect of these inadequacies is that most backfit issues were not resolved in the spirit we believe the Commission intended when the interim procedures were approved for implementation." The report also concluded that the guidance provided to NRC staff lacked "... the necessary specificity to allow the staff to adequately manage and control issues defined as backfits. . . ."

At the time of our review, the CRGR staff stated that NRC management was considering steps to reduce the problem of staff imposition of backfits outside of established processes. They said that NRC intended to conduct training programs for its staff to (1) make them better understand what actions constitute backfitting, (2) apprise them of the potential effects of new backfitting requirements, and (3) instruct the staff on the procedures to be followed when imposing new requirements. Further, the CRGR staff stated that utilities have to take a more active role in identifying apparently unauthorized backfitting situations. They pointed out that utilities are performing informally imposed backfits in some instances and that utilities must realize that they should not be performing these actions under those circumstances. They stated that the utilities need to make senior NRC management aware of instances in which informal backfits are being required. The CRGR staff added that they intend to hold meetings with high-level officials at each utility operating or building nuclear power plants to apprise the officials of

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current NRC backfitting initiatives, including utilities' crucial roles in controlling backfits.

## Adequate Analysis of New Backfitting Requirements Not Performed

Analysis and justification—from the standpoint of improved safety, utility costs, radiation exposure to plant workers, and the technical merits of each proposed new regulatory requirement—is essential to effective NRC management of backfits. An adequate and documented justification provides a legitimate basis for each new requirement and allows senior NRC management to weigh the costs and benefits of proposed backfits before they are imposed. NRC's analyses and justifications for generic and plant-specific backfitting requirements, however, have not been as thorough and complete as required by the directives that implemented these backfitting management processes.

### Analysis of Generic Backfitting Requirements Weak but Improving

A major feature of NRC's efforts to provide a more disciplined backfitting process is the requirement that each proposed generic requirement sent to the CRGR for review include an assessment of the risk reduction that will result from the backfit and an estimate of the impact of the requirement on NRC and the utilities. The impact estimate on utilities is to include estimated increases or decreases in radiation exposure to workers, added operational complexity of the plant, and total financial costs. The technical analyses and cost assessments are required to assist the CRGR in making informed judgments on the safety benefits and priorities of the backfits to be imposed.

The documentation and analyses to support risk reduction, costs, and benefits, however, have not been adequately developed by the technical staffs. The March 1984 report by NRC's Office of Inspector and Auditor regarding the CRGR's operations noted that the NRC technical staff have not fully complied with NRC's requirement that quantitative analyses of proposed generic requirements be performed and provided to the CRGR. The report stated that proposed requirements reviewed by the CRGR did not usually contain any quantitative analysis of risk reduction or assessments of costs to NRC and the affected utilities. When these analyses were performed, the report noted, they were generally insufficient.

Our discussions with CRGR staff, supplemented by a review of backfitting data, supports the findings of the NRC audit report. The staff stated that analysis of backfits has been limited because the NRC staff initiating backfits were not familiar with these analytical techniques and agency expertise was insufficient to correct the problem. We also examined



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seven generic backfits in detail and found that none contained all the required analyses.

The CRGR staff also stated, however, that recent NRC staff analyses of proposed backfits are improving and are more comprehensive. For example, the staff originating proposals for resolving the station blackout problem (which addresses the ability of nuclear plants to continue to cool and control the reactor during the loss of electrical power for extended periods) performed detailed analyses to show that the proposed actions could (1) reduce the probability of this type of accident to 1 in 100,000 reactor years of operation, (2) cost the industry $140 million, and (3) be within acceptable limits regarding worker exposure to radiation.

CRGR staff stated that they are now much stricter in their acceptance of proposed requirements for CRGR review and are ensuring that the proper analyses are performed. The Chairman of the CRGR stated that he believes the NRC technical staff now understand what type of quantitative analysis is required and that this problem is essentially resolved.

### Adequate Documentation and Justification Not Provided Under Plant-Specific Backfitting Process

Like the justification process for generic backfits, the plant-specific backfitting process is intended to ensure that these proposed backfits are adequately documented and justified. Although this process provides documentation and justification steps, they have not always been followed.

Under the plant-specific backfitting process, before the proposed backfit is transmitted to the affected utility, NRC staff are required to document and justify the action by providing a brief written statement, approved by the appropriate Assistant Director in the Division of Licensing, Office of Nuclear Reactor Regulation, of how the backfit will improve safety. If the proposed backfit is appealed by the utility, NRC staff will then perform a cost-benefit analysis of the new requirement. However, there has been little NRC technical staff justification for the requirements imposed under the plant-specific backfitting process. For example, of the 25 plant-specific backfits that we examined, in only 6 cases did the NRC staff develop statements related to the safety benefits of the backfits before they were imposed, and in one of these instances, an internal NRC memorandum criticized the benefit statement as not providing a sufficient basis for requiring a backfit.

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Utility officials observed that a significant problem with NRC's plant-specific backfitting process is that the utility must appeal the imposition of a new requirement before the NRC staff will perform a cost-benefit study. They added that the cost of an appeal will protect many backfits from this needed scrutiny. According to NRC's own estimate, it can cost a utility as much as $100,000 to appeal a new requirement. The cost incurred includes utility and utility contractor resources required to do the necessary analysis to support its appeal and administrative costs such as travel. Consequently, utility representatives stated that unless a plant-specific backfit is very costly or could be a clear detriment to safety, it is easier and less expensive to install the backfit—even if the utility believes it has no safety benefit—than to appeal the backfit through NRC.

NRC senior management officials in the Office of Nuclear Reactor Regulation and the Office of the Executive Director for Operations agreed that some problems have occurred because of the NRC staff's lack of familiarity and experience with the current backfitting processes. Other NRC officials told us that, in their opinion, many of the plant-specific requirements that industry had complained about involve compliance with existing NRC requirements rather than the imposition of new requirements. As discussed in chapter 2, we found that about 35 percent of the costs of what utilities considered as backfits at 7 plants involved bringing these plants into compliance with existing NRC requirements. The remaining 65 percent of these costs, however, related to what can legitimately be called backfitting.

## NRC Has Not Used Its Backfitting Regulation

Historically NRC has not used its backfitting regulation when requiring changes at nuclear power plants. That is, NRC has not used the term "backfit" in correspondence to utilities that imposed new regulatory requirements on their plants, did not cite its backfitting regulation as its authority for imposing the new requirements, or make an explicit finding that new regulatory requirements ". . . will provide substantial additional protection which is required for the public health and safety or the common defense and security." This, in great part, has been responsible for

- NRC's inability to determine the magnitude or impact of its past backfitting actions,
- utility uncertainty over what actions NRC was requiring to be performed, and



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- NRC's imposition of backfits that may not have been necessary because they resulted in questionable safety benefits.

NRC has not addressed this problem in its initiatives to control backfitting. Under its current backfitting procedures, NRC staff has not used the backfitting regulation as its authority for requiring plants to make changes. In no instance from the establishment of the generic and plant-specific backfitting processes until we completed our review had NRC formally required a backfit to be performed in accordance with the regulation or explicitly determined that a new requirement to be imposed will provide substantial additional protection. Only in the instance of a backfit imposed in accordance with the plant-specific procedures did NRC even identify new requirements as backfits. Consequently, backfitting in accordance with the authority and intent of the backfitting regulation was still not being performed.

## NRC Backfitting Actions After Our Audit Work

In commenting on our report, NRC pointed out that it took two major actions since we completed our audit work in April 1985. First, it revised its plant-specific backfitting management procedures. Although the revised procedures were issued in draft form, they went into effect on May 1, 1985. Final procedures, according to NRC, will be issued to conform to the new backfitting rule—the second major NRC action. NRC said that on August 1, 1985, the Commissioners approved a rule that amended its backfitting regulation. The rule went into effect on October 21, 1985.

## Revised Plant-Specific Backfitting Procedures

The revised NRC plant-specific backfitting procedures differ from the procedures described earlier in this chapter in three important ways. First, they require a systematic and documented technical and cost-benefit analysis before a proposed backfit is imposed on a plant. Under the old procedures, this analysis was required only when a utility appealed a backfitting decision. Second, a plant-specific backfit and supporting analysis must be approved by an NRC staff officer at the office director, regional administrator, or deputy director or administrator level, without further delegation, before the backfit and analysis are transmitted to the utility. Under the old procedures, staff at lower levels were authorized to transmit plant-specific backfits—without supporting analysis—to utilities.

Third, the NRC staff are now required to include an analysis describing how the proposed backfit meets the definition of a plant-specific

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backfit. The revised procedures state that a plant-specific backfit is defined by "... the substance of the elements of the proposed staff position ..." and the time of the identification of the proposed position. In elaboration, they state that a backfit is a staff position that would cause a utility to change the design, construction, or operation of a plant from that consistent with regulatory staff positions that already apply to the plant, and that a new position is being adopted after NRC approvals have been given for the design, construction, or operation of the facility.

The revised procedures do not, however, distinguish between proposed staff positions that could only apply to a specific plant (a plant-specific backfit) and positions that are applicable at more than one plant (a generic backfit). In addition, as discussed earlier, most backfits identified under the former procedures were initially identified by utilities from new or revised regulatory requirements transmitted to them by the NRC staff. The revised plant-specific backfitting procedures state that the NRC staff shall be alert to the possibility that certain staff positions may be recognized and identified as plant-specific backfits. They also state that the NRC staff will promptly consider a utility claim of backfit to determine whether the claimed backfit qualifies as a plant-specific backfit. However, the new procedures do not clearly state that the NRC staff—not the utilities—have the primary responsibility to identify and obtain appropriate review of potential plant-specific backfits before they are transmitted to utilities.

We discussed these two apparent weaknesses with the official in NRC's Office of the Executive Director for Operations responsible for revising them. This official agreed that the distinction between plant-specific and generic backfits should be sharpened and that the procedures should emphasize the NRC staff's primary responsibility to identify and obtain reviews of potential backfits before transmitting them to utilities. The official stated that these weaknesses will be corrected in the final version, soon to be issued, of the plant-specific backfitting procedures.

In addition to establishing backfitting management controls, NRC changed its backfitting regulation. In September 1983 NRC published an advance notice of proposed rulemaking in the Federal Register seeking the views of the electric utility industry and the public on various backfitting proposals and alternatives for the long-term management of backfitting. Subsequently, on November 30, 1984, NRC issued a notice of proposed rulemaking for the purpose of establishing requirements for the long-term management of backfitting. Finally, on August 1, 1985, the NRC Commissioners approved a new backfitting rule. The rule went



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into effect on October 21, 1985. The major features of the new backfitting rule, and how they compare with the regulation adopted in 1970, are

- The definition of backfitting—NRC defined backfitting as the modification of or addition to systems, structures, components, or design of a facility; or the design approval or manufacturing license for a facility; or the procedures or organization required to design, construct, or operate a facility; any of which may result from a new or amended provision in the Commission rules or the imposition of a regulatory staff position interpreting the Commission rules that is either new or different from a previously applicable staff position. The previous backfitting regulation simply defined backfitting as changes to structures, systems, or components after a construction permit is issued.
- NRC's basis for justifying the need for backfitting actions—The new rule states that NRC will require backfitting only when it determines—on the basis of systematic and documented analysis—that a backfit will substantially increase overall safety protection, and the direct and indirect costs of implementing it are justified in view of this increased protection. The previous backfitting regulation did not require NRC to document its analysis, determine the additional increase in safety protection, or justify the backfit in relation to its cost. In addition, it did not refer to "overall" safety protection.
- Factors to consider in determining whether a backfit is justified—The new rule identifies nine factors that NRC must consider: (1) the specific objectives that a proposed backfit is designed to achieve, (2) a general description of the utility activity that would be required to complete the backfit, (3) the potential reduction in risk to the public from accidental off-site release of radioactive material, (4) the potential radiological exposure to plant workers, (5) the installation and continuing costs of the backfit, including plant downtime, (6) the potential safety impact of changes in plant operational complexity, (7) the estimated resource burden on NRC, (8) the potential impact of differences in plant types, designs, or ages on the relevancy and practicality of the proposed backfit, and (9) if the backfit is to be imposed on an interim basis, the justification for that basis. These factors are used in a broad range of NRC regulatory activities and are contained in an agency publication entitled Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission. The previous backfitting regulation did not discuss the factors that NRC must consider to justify the backfits.

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## Conclusions

Backfitting is an important regulatory tool to help ensure that nuclear power plants are properly constructed and safely operated. NRC has not, however, used its backfitting regulation when imposing new or revised regulatory requirements on plants under construction or in operation, nor has it explicitly determined that the requirements it imposed offered "substantial additional protection" necessary for the public health and safety. Instead, NRC has traditionally imposed new regulatory requirements by obtaining utilities' commitments to follow the most current NRC staff guidance or interpretations of the agency's regulations as part of its license and license amendment review processes. The effect of these practices has been that NRC used non-binding guidance to impose new requirements on nuclear power plants.

In the aftermath of the Three Mile Island accident, NRC management discovered that the agency was imposing new regulatory requirements at a pace that had created a potential safety problem. NRC found that, at a minimum, this had led to (1) backfits with little or no safety benefits, (2) backfits that may have actually reduced plant safety, (3) confusion over regulatory requirements, (4) delays in plant operations, and (5) increased maintenance and scheduling difficulties for utilities.

NRC recognized that it needed better management of backfitting to ensure that each backfit had a positive overall safety benefit and that the benefit was worth the cost. Therefore, NRC established

- a process requiring senior management review and approval of generic backfits on the basis of anticipated safety benefits, costs, proposed implementation schedules, and priorities relative to all other NRC regulatory activities at affected plants;
- a process for reviewing new plant-specific requirements and providing utilities with the opportunity to appeal NRC staff decisions to impose the requirements; and
- a procedure for integrating NRC backfits with utilities' long-range plant operating and maintenance plans.

Although the generic and plant-specific backfitting processes that NRC implemented in the 1981-to-1983 time period provided some discipline and management control to backfitting, the NRC staff continued to impose new regulatory requirements outside of these processes. In addition, some backfits imposed under the plant-specific backfitting process were based on generic requirements but were not being subjected to prior CRGR review and approval. If these backfits were important to safety, then it follows that NRC needed to consider them generically and,



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if appropriate, impose them on all applicable plants. Finally, generic and plant-specific backfits were imposed without the analysis and documentation required by NRC's backfitting processes.

NRC's backfitting management initiatives were not entirely successful for two interrelated reasons. First, to be effective, NRC managers and staff at the lowest organizational levels must recognize apparent backfits before imposing them on plants. However, there was confusion and disagreement within NRC and between NRC and utilities over what constituted backfitting. The probable maximum precipitation example discussed earlier illustrates this point. In that case the position of the particular NRC staff was that they were merely applying the latest available technical information in their evaluation of the utility's operating license application. The staff did not believe that applying the new information constituted a backfit or a new regulatory requirement. On the other hand, the particular standard—the new information—that the NRC staff were using had clearly changed from the standard contained in NRC's Standard Review Plan, and NRC management had not reviewed and approved this deviation from the published Standard Review Plan.

Second, effective management of backfitting requires that lower-level NRC managers and technical staff accurately assess whether a potential backfit is generic or plant-specific and then submit the potential backfit for the appropriate review. This was not always done. Further, this situation was exacerbated by weaknesses in both the generic and plant-specific backfitting review processes. Specifically, allowing the NRC staff to determine which generic documents are to be forwarded to the CRGR for review weakens control of generic documents by the Executive Director for Operations, including those that would backfit plants under construction or in operation. In addition, NRC's October 1983 plant-specific backfitting process called for senior-management review of backfits and analysis of costs and benefits only if utilities appealed low-level NRC staff decisions to impose new requirements on their plants.

Thus, the key to effective and efficient management of backfitting is instilling in NRC managers and staff at all levels the practice of identifying potential backfits and referring them to the appropriate channels for resolution as a routine part of the business of regulating nuclear power. Using the agency's backfitting regulation as the cornerstone of a backfitting management system containing the four features discussed next is the best way to accomplish this.

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First, the term "backfitting" must be defined in a way that is compatible with NRC staff regulatory practices to help eliminate the confusion over what constitutes backfitting. NRC has accomplished this in its new backfitting rule by equating backfitting to the imposition of new or modified NRC regulations or regulatory staff positions interpreting the regulations.

Second, NRC should use its backfitting regulation. That is, NRC's policy should be that utilities are under no obligation to comply with new or revised regulations or regulatory staff positions that their plant construction permits or operating licenses do not commit them to follow unless NRC takes one of the following actions:

- NRC imposes the regulation or staff position by explicitly stating that it has determined, in accordance with its backfitting regulation, that such action provides a substantial increase in the overall protection of the public health and safety or the common defense and security and that the direct and indirect costs of implementation are justified in view of this increased protection.
- The backfit is imposed by an NRC official specifically (and publicly) authorized to make generic and/or plant-specific backfitting determinations.
- The NRC official imposing the backfit provides the affected utilities with the analysis used to make the backfitting determination. For both generic and plant-specific backfits, the analysis should be prepared in accordance with NRC's Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission.

The combination of the final backfitting rule and the current generic and plant-specific backfitting management procedures largely put such a policy into effect as of October 21, 1985. Taken as a whole, the rule and the procedures now (1) define backfitting in terms that are consistent with staff regulatory practices, (2) limit backfitting decisions to the Executive Director for Operations, office directors and regional administrators, or deputy directors and administrators, (3) require all backfitting decisions to be made on the basis of systematic and documented analysis covering nine specified factors, and (4) require decision makers to provide affected utilities with the analysis used to make backfitting decisions.

However, because under the original plant-specific backfitting procedures the utilities, rather than the NRC staff, were initially identifying plant-specific backfits, NRC needs to emphasize in its new plant-specific


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backfitting procedures that the primary responsibility for identifying new or revised staff positions that apply to a single plant, and performing technical and cost-benefit analyses that support the backfit—before it is transmitted to utilities—rests with the NRC staff.

Third, before imposing a plant-specific backfit, NRC should determine whether the proposed backfit may also be applicable at other plants. In making this determination, NRC should focus its analysis on the technical basis for the proposed backfit and whether that basis is derived from unique features of the applicable plant or from NRC staff positions that also apply to other plants. Although this is important to ensure that proposed backfits receive the appropriate generic or plant-specific review, it is particularly important to ensure that safety improvements that NRC determines are necessary at one plant are also realized, if appropriate, at other plants. NRC's draft plant-specific backfitting management procedures, in effect since May 1, 1985, require that the analysis of a proposed plant-specific backfit describe how it qualifies as plant-specific. The definition of a plant-specific backfit contained in the draft procedures, however, does not provide an adequate distinction between a plant-specific and a generic backfit.

Finally, as an additional internal control measure, NRC should periodically assess the performance of NRC managers at all levels in implementing NRC's backfitting regulation and management procedures to ensure that the agency staff is not imposing backfits outside of the prescribed backfitting processes. This is a particularly important step because our review and the June 1985 report by NRC's Office of Inspector and Auditor found that under the October 1983 plant-specific backfitting procedures the NRC staff were still not identifying and processing new staff positions as backfits before transmitting them to utilities. Instead, the NRC staff continued to rely on utilities to identify backfits. NRC, in commenting on our draft report, stated that it has taken action in this area.

## Recommendations to the Chairman, Nuclear Regulatory Commission

Effective October 21, 1985, NRC had a comprehensive backfitting management system in place that relies on its backfitting regulation as its foundation. To provide additional assurance that the system is operating effectively, we recommend that the Chairman, NRC, revise the agency's plant-specific backfitting procedures to explicitly state that

- the NRC staff are responsible for identifying and processing, in accordance with the plant-specific backfitting procedures, all new or amended plant-specific positions taken by the staff and

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- to qualify as a plant-specific backfit, the technical basis for a new or revised staff position taken must be unique to a specific plant or plant location.

## Agency Comments and Our Evaluation

In commenting on a draft of this report, NRC agreed that there are several areas where further work to improve its backfitting process is desirable and that it has and is acting to improve those areas. NRC specifically cited several important actions taken after completion of our audit work to strengthen plant-specific backfitting management. We agree that these actions should strengthen its management of backfitting and have revised the report to reflect them.

In our draft report, we proposed that NRC

- define backfitting as the imposition of new or modified regulatory requirements after a construction permit has been issued and
- establish a policy that utilities must comply with NRC staff regulatory requirements not covered by their plant licenses only when a designated agency official explicitly determines that such requirements must be imposed because they offer substantial additional protection and provides the affected utilities with the bases for those determinations.

NRC commented that the new backfitting rule approved by the Commission on August 1, 1985, defines backfitting in a way that is fully responsive to our proposed recommendation. NRC said the rule also permits backfitting only when the agency determines, on the basis of a systematic and documented analysis, that a proposed backfit offers a substantial increase in overall protection. Finally, NRC pointed out that its May 1, 1985, plant-specific backfitting procedures require senior management approval of proposed backfits and accompanying analysis.

We agree that the final backfitting rule, in conjunction with the generic and plant-specific backfitting procedures now in effect, largely responds to our two proposed recommendations. Therefore, we deleted the recommendations from the final report. However, because the current plant-specific backfitting procedures do not clearly state that it is the NRC staff's responsibility to make the initial identification of plant-specific backfits, we recommended that the procedures be revised accordingly.

In our draft report we had proposed that the Chairman, NRC, assess the NRC staff's backfitting management performance. NRC commented that



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all affected senior executive service managers have had backfitting performance criteria established in their service performance plans since January 1985. In addition, NRC said, a computerized plant-specific backfitting information system has been in place since June 1985. One purpose of the system is to assemble and analyze data for periodic reports to the Commission. We believe these actions provide NRC with the capability to satisfactorily implement our proposed recommendation and we have deleted it from the report. However, we believe that it is important that the Chairman give particular attention to the critical area of the initial identification of potential backfits in carrying out these assessments.

In our draft report we also proposed that the Chairman, NRC, document the technical basis for proposed backfits and determine whether the basis is derived from features unique to a plant or an NRC position that is applicable to other plants. Although NRC did not address this proposal in its comments, its current plant-specific backfitting management procedures require that analysis of a proposed plant-specific backfit describe how the proposed backfit qualifies as plant-specific. Therefore, we deleted this proposal from our final report. However, because the current procedures do not clearly define plant-specific backfits, as distinguished from generic backfits, we recommended that NRC appropriately define a plant-specific backfit.

NRC also highlighted recent actions to improve backfitting management that are supportive of the final backfitting rule and current plant-specific procedures. NRC stated that it has (1) developed procedures at headquarters and regional offices, which are involved in the licensing and inspection of nuclear power plants, to incorporate the recent changes in the plant-specific backfitting guidance, (2) conducted staff training seminars at regions and headquarters offices on how to identify and manage backfits, and (3) implemented a data base to record and track backfits. Finally, the Executive Director for Operations plans to inform each utility of the revised plant-specific backfitting procedures.

We agree with NRC's view that these actions are positive steps towards correcting the backfitting management weaknesses described in this report.

The full text of NRC's comments is included in appendix I.

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# Advance Comments From the Nuclear Regulatory Commission

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SEP 13 1985

Mr. J. Dexter Peach, Director
Resources, Community, and
Economic Development Division
U.S. General Accounting Office
441 G. Street, N.W.
Washington, D.C. 20548

Dear Mr. Peach:

We appreciate the opportunity to comment on the draft GAO report "Additional Improvements are Needed in the Nuclear Regulatory Commission's Procedures for Backfitting Changes into Nuclear Plants." The report makes several points which are useful to the Nuclear Regulatory Commission, and it highlights several areas in which we agree that further work by NRC is desirable. We have and are acting to improve those areas.

A primary thrust of your report is that the NRC is backfitting excessively and too often without adequate justification. We welcome your agreement that several NRC initiatives have improved our backfit management process. Given that there will be deviations from optimum performance for some time as major revisions are wrought in NRC policy and practice, I believe that we must assure that any error is in the direction of assuring the safe design, construction, and operation of nuclear plants. I will act to assure that any difficult backfit decisions are made with that objective in mind.

We note that the review on which the report is based was finished in April 1985, which could account for the lack of recognition of several important NRC actions taken in 1985 to strengthen our performance with respect to plant-specific backfit management. These actions are described in our specific comments on your recommendations enclosed. Under separate cover, I am forwarding a copy of a report by our Office of Inspection and Auditor, issued June 21, 1985, which also provides an informed response to your recommendations, and shows that the Commission has implemented changes to more effectively manage plant-specific backfits.

Sincerely,

William J. Dircks
Executive Director for Operations

Enclosure:
Comments on GAO Recommendations

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SPECIFIC COMMENTS ON DRAFT GAO REPORT

"Additional Improvements are Needed in the
Nuclear Regulatory Commission's Procedures
for Backfitting Changes into Nuclear Plants"

1. Comments on GAO Recommendations (Executive Summary)

   a. Define backfitting as the imposition of new or modified regulatory requirements after a construction permit has been issued.

      Response - A final rule amending 10 CFR 50.109 was approved by the Commission at a public meeting on August 1, 1985. This rule defines backfitting in clear terms and in a manner that we feel is fully responsive to the GAO recommendation.

   b. Establish a policy that utilities must comply with NRC staff regulatory requirements not covered by their plant licenses only when a designated agency official explicitly determines that such requirements must be imposed because they offer substantial additional protection and provide the affected utilities with the bases for those determinations.

      Response - The amended 10 CFR 50.109 as approved by the Commission explicitly states that the Commission shall require the backfitting of a facility only when it determines, based on a systematic and documented analysis, that there is a substantial increase in the overall protection of the public health and safety or the common defense and security to be derived from the backfit.

      Policy guidance for the staff is expressed in draft Manual Chapter 0514, issued on April 12, 1985 from the Office of the Executive Director for Operations. Draft MC-0514 states that the documented Regulatory Analysis prepared in support of a backfit action will be approved by an Office Director or Regional Administrator and transmitted to the plant owner with the statement describing the proposed backfit action.

   c. Periodically assess the performance of NRC managers and staff in carrying out the agency's backfit regulation, policies, and procedures.

      Response - Since January 1985, all Senior Executive Service managers whose assignments involve the identification and management of backfit actions have had performance criteria relative to backfitting established in their SES performance plans. In addition, the Plant-Specific Backfit System, a computerized, interactive terminal data base has been in place since June 1985, providing the current status of each backfit action initiated by either the NRC staff or by



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a licensee. This information, entered in the system by users in all Regional Offices and three headquarters offices, will be used to maintain a current management knowledge of how backfit actions are managed and resolved with respect to standing policy and also to assemble and analyze data for periodic reports to the Commission.

2. General Comment on Overall Report.

Now on p. 20.

The GAO draft on page 13 indicates that information gathering for this review was completed as of April 1985. Several significant NRC actions have been taken since that time regarding backfit management. Those actions are described briefly here because the actions explicitly addressed the greater issues that have been identified by GAO as deficiencies in NRC backfit management:

(a) A revised draft NRC Manual Chapter 0514 was implemented on May 1, 1985. It is a substantial revision of the previous Manual Chapter issued on April 20, 1984. The revision was based on public comments, staff comments, and a management review of staff progress in managing backfitting during 1984. Among other changes, the May 1985 document clearly defines backfitting and includes an Appendix that describes how backfitting can be recognized in several typical NRC staff activities.

(b) The three headquarters offices involved in licensing and inspection activities and all five regional offices are preparing detailed office procedures to implement the policy guidance in the Manual Chapter. All regional offices and two headquarters offices have received approval of their office procedures as of September 1, 1985. The Manual Chapter and office procedures will undergo final revision when the new backfit rule approved by the Commission is published. Only minor revisions are expected.

(c) Seminars in all regions and four headquarters offices have been conducted to train the staff how to identify backfit issues and how to conduct the backfitting process in the context of the procedures and the Manual Chapter. Approximately 600 managers and nonmanagers participated in these meetings. The seminars have been reported to be extremely valuable in ensuring that the staff understands the approved backfitting principles and objectives.

(d) The Plant-Specific Backfit System (PSBS) has been designed and implemented (June 1985) to establish a recordkeeping and reporting data base for monitoring the efficacy of the backfit control measures. This is an agencywide data management system that provides access to a common data base at headquarters and regional offices by microcomputer work stations at each locations. The PSBS provides for the entry, modification, and retrieval of data by all using offices.

(e) Management of backfitting was established as an explicit performance elements in all SES contracts as of January 1985.

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(f) The EDO plans to issue a generic letter to all utility licensees advising them of the revised plant-specific backfit process and soliciting their response regarding implementation problems. Following that issuance, meetings may be arranged as deemed appropriate and useful to explain the principles and objectives of the backfit policy to the regulated industry.



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# Utilities Contributing Data to GAO

| Utility | Unit | State | Type | Year of Commercial Operation |
|---|---|---|---|---|
| Arkansas Power & Light Co. | Nuclear One 1 | AR | PWR | 1974[a] |
| | Nuclear One 2 | AR | PWR | 1980[a] |
| Carolina Power & Light Co. | Brunswick 1 | NC | BWR | 1977 |
| | Brunswick 2 | NC | BWR | 1975 |
| | Robinson | SC | PWR | 1971 |
| Commonwealth Edison Co. | Dresden 2 | IL | BWR | 1970 |
| | Dresden 3 | IL | BWR | 1971 |
| | Quad Cities 1 | IL | BWR | 1972 |
| | Quad Cities 2 | IL | BWR | 1972 |
| | Zion 1 | IL | PWR | 1973 |
| | Zion 2 | IL | PWR | 1974 |
| | LaSalle County 1 | IL | BWR | 1982 |
| | LaSalle County 2 | IL | BWR | 1984 |
| Consumers Power Co. | Palisades | MI | PWR | 1971 |
| | Big Rock Point | MI | BWR | 1971 |
| Duke Power Co. | Oconee 1 | SC | PWR | 1973 |
| | Oconee 2 | SC | PWR | 1974 |
| | Oconee 3 | SC | PWR | 1974 |
| | McGuire 1 | NC | PWR | 1981 |
| | McGuire 2 | NC | PWR | 1984 |
| Duquesne Light Co. | Beaver Valley 1 | PA | PWR | 1977 |
| | Beaver Valley 2 | PA | PWR | 1987[a] |
| GPU Nuclear Corp. | Oyster Creek | NJ | BWR | 1969 |
| | Three Mile Island 1 | PA | PWR | 1974 |
| Indiana & Michigan Electric Co. | Donald C. Cook 1 | MI | PWR | 1975 |
| | Donald C. Cook 2 | MI | PWR | 1978 |
| New York Power Authority | Indian Point 3 | NY | PWR | 1976 |
| | James A. Fitzpatrick | NY | BWR | 1975 |
| Niagara Mohawk Power Co. | Nine Mile Point 1 | NY | BWR | 1969 |
| Northeast Utilities | Haddam Neck | CT | PWR | 1968 |
| | Millstone 1 | CT | BWR | 1970 |
| | Millstone 2 | CT | PWR | 1975 |
| Northern States Power Co. | Monticello | MN | BWR | 1971 |
| | Prairie Island 1 | MN | PWR | 1973 |
| | Prairie Island 2 | MN | PWR | 1974 |
| Omaha Public Power District | Fort Calhoun 1 | NE | PWR | 1973 |
| Philadelphia Electric Co. | Peach Bottom 2 | PA | BWR | 1974 |
| | Peach Bottom 3 | PA | BWR | 1974 |
| Portland General Electric Co. | Trojan | OR | PWR | 1976 |
| Sacramento Municipal Utility District | Rancho Seco | CA | PWR | 1975 |
| South Carolina Electric & Gas Co. | Virgil C. Summer 1 | SC | PWR | 1984 |
| Tennessee Valley Authority | Browns Ferry 1 | AL | BWR | 1974 |
| | Browns Ferry 2 | AL | BWR | 1975 |
| | Browns Ferry 3 | AL | BWR | 1977 |
| | Sequoyah 1 | TN | PWR | 1981 |
| | Sequoyah 2 | TN | PWR | 1982 |
| Toledo Edison Co. | Davis Besse 1 | OH | PWR | 1977 |

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| | | | | |
|---|---|---|---|---|
| Union Electric Co. | Callaway 1 | MO | PWR | 1985 |
| Wisconsin Electric Power Co. | Point Beach 1 | WI | PWR | 1970 |
| | Point Beach 2 | WI | PWR | 1972 |
| Wisconsin Public Service Corp. | Kewaunee | WI | PWR | 1974 |
| **22 Utilities** | **51 Units** | **32**<br>**19** | **PWR**<br>**BWR** | |

[a]Unit not yet in service - projected year of operation.



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